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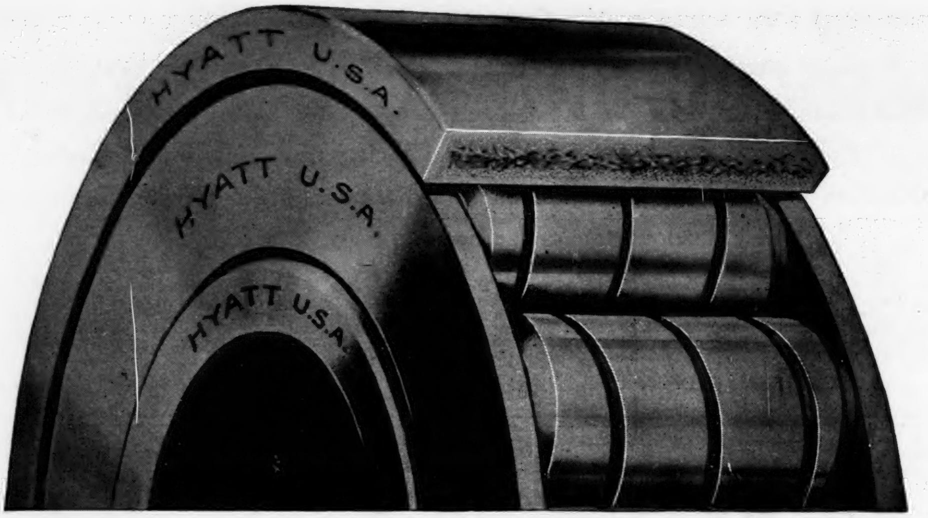

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AGRICULTURAL ENGINEERING

The Journal of Engineering as Applied to Agriculture

Vol. 8 OCTOBER, 1927 No. 10

Manufacturing Wheat on a 95,000-Acre Farm Factory*

By Thomas D. Campbell[1]

Thomas D. Campbell

THE question is often asked me when talking to financial people, "How do you know you are going to succeed? What makes you think you can save your crop? What makes you think you can raise it?" I maintain that an engineer can present the same data, that will give assurance on those points, as he can on any other contracting job. For instance, government records have been kept for years and years on rainfall. And it is just a question of timing yourself, so you keep within the hazardous dates. Just don't try to raise wheat where the rainfall is less than what is necessary to produce a crop.

There is no more hazard in saving a crop, if you are properly equipped, than there is in getting out a certain amount of iron, or a certain number of logs, or a certain commodity of any other kind. But the farmer so far never has been adequately equipped. One reason is that it requires about $10.50 per acre investment in machinery in order to do the work in the seasonal limits. That is a startling amount, hardly ever believed. If that is necessary on a large scale, obviously it would require more on a small scale.

Now I am not advocating that every farmer should be a large scale farmer, but all farming should be industrialized. I know we will always have the small farmer, and I hope we always do. I read an attack in an agricultural paper this morning on our method of farming, which accused us of contending that all farming had to be done as we do it. A statement like that is utterly absurd. We will always need the small farmer, and he will be successful if he has no other labor expense than his own family payroll.

We maintain there are but two kinds of farming left under present economic conditions. There is the small farmer, where the man and his family do all the work; and there is the large farm, operated by engineers on an industrial basis, with high-priced management, highly skilled labor, and large machines, so the output per man will be increased.

Our minimum wage is $6.00 a day, plus a bonus at the end of the year, which I will tell you about later. And I maintain that if we get only $1.00 a bushel, our minimum wage will be $10.00 a day. The only way we can compete with a low price is to increase the wages.

I have a moving picture which I have cut down so we can run it in half an hour. I believe it will be better if we run the picture and I will explain some of the things which might not be easily recognized.

We try to take a great deal of interest in our men. This is one of our good men. [Motion picture shows smith forging plowshare.] Just for the psychology of it, we put some of them in the picture.

When it is dry we have to change plows twice a day. We would like to have some plow manufacturer make a plowshare of some material which would not make it necessary to change them so often. We use moldboard plows in sod breaking. We plow 4 in. deep so we will have a seedbed after we raise a flax crop. After the first plowing we use disk plows, because they are more economical. If we could get the bearings to stand up on them, we would be better satisfied.

We do not use much agronomy in selecting our land. We go out on the prairies and pick a large, level tract with a uniform growth of grass. They say that is the way James J. Hill decided the Red River Valley was a wheat country. He never analyzed the soil, but he knew by the uniform growth of grass and the height of it that the soil had lots of nitrogen in it.

We are still using large, old-style tractors. They have proven very serviceable, and have been running for eight years. They were a splendid design at the time, but they had only one gear. If you wanted to change gears, it took about four hours. As everyone knows, with a traction engine with one gear, the maximum load is limited to its maximum grade with that gear. Our tractor operators work on a $6.00 a day rate, with ten cents a mile bonus, beginning with mile No. 1. The bonus is paid if they stay throughout the season. The bonus accumulates each month, and they are given credit for it. If they leave for any reason other than sickness, or are discharged for inefficiency, or for disloyalty, they forfeit their bonus.

We have plowed from daylight to dark, being about 16 hr. in our country, 640 acres of land with fifteen tractors of the 30-60-hp. type, without one stop for mechanical troubles of any kind. I used to attend tractor demonstrations, where most of the tractors were operated by factory experts, and I have never seen a demonstration yet where they got more than two or three times around an acre lot without changing a spark plug or making some other adjustments. And I wondered just why these things were necessary.

[Motion picture showed a three-drill outfit.] We don't use many three-drill outfits now; we operate five-drill outfits, attached to the tractor by means of an improved Hansmann hitch. The outfits shown have no packers on them, but as a regular thing we use heavy packers. We find that it prevents 90 per cent of the winter kill, which is a very necessary thing for people to learn.

The packer is no good without a load. As far back as I can remember I have heard it said as an objection to farming with a tractor that the tractor wheels packed the ground. But we find in our work that wherever the tractor wheels run—unless the soil is gumbo—that is where we got the best crops. That is why we load our packers down. We try to get 300, 400, or 500 lb. on them. And, of course, when we put on the load that ruins the bearings and everything else.

Our standard harvesting outfit in the beginning was a tractor and six binders operated at two miles an hour, which was factory speed. We got another speed and found it more economical to run four binders at 3 mi. an hour. We had less trouble, especially hitch trouble.

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*An address (accompanied by moving pictures) before a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1926.

[1]President, Campbell Farming Corporation. Mem. A.S.A.E.

This picture shows Mr. Campbell's new method of windrow harvesting, using four 10-ft. binders. It saves time, eliminates three binder operators, twine and shocking costs, reduces gasoline consumption, and makes the "combine" one hundred per cent efficient. The combine follows, and a hayloader attached to the combine elevates the grain from the windrow, and a conveyor delivers it to the cylinder of the combine

I was surprised to hear one of the speakers at the session yesterday say he hastened maturity of the crop by seeding as high as 1¾ bu. per acre. That would mean ruination to us because of our limited rainfall. We seed only 20 lb. per acre, because we have learned that there is just enough rainfall to mature that many stalks. If we seed more per acre, we have so many stalks that none of them mature, excepting small, short talks, and we would thresh out probably 2 or 3 bu. per acre.

In regard to the economic side of farming there is the matter of the efficient size of unit. I think it is generally recognized that practically every other industry has determined definite economic units. But I know of no such attempts having been made in the agricultural industry. We have learned that it is absolutely impossible for a farmer to succeed on the regular 160-acre homestead, such as was allotted by the government all through the Northwest. We find on our job that the average net earnings per acre are from $2.00 to $2.50 with the most efficient methods and with all the advantages we may get in marketing. With 160 acres of land that net earning makes $320 to $400 per year. A farmer with only that amount of land had better go and take a job in a factory. In fact, the farmers in our immediate vicinity have abandoned their farms and are working for us. They make excellent tractor operators, for they have paid some bills themselves and they know what it is. They earn $6.00 a day or more, their wives are contented and happy, and they have not the anxieties and cares they had before.

On that basis, we maintain that 2,000 acres should be the minimum size of farm. I feel that 640 acres would be the minimum. That would reduce the overhead and eliminate the duplication of buildings and machinery. The overhead would be $3.00 or $4.00 an acre.

I am interested in telling you about our new method of farming, especially after the discussion we had on the combine at the meeting yesterday. I think it was clearly demonstrated yesterday that the combine has three principal objections: The grain has to be dead ripe, it has to be uniformly ripe, and it has to be free from weeds. Instances were reported where combined grain was threshed so damp that it stuck in the spout. We couldn't deliver any grain out in our country that damp. We deliver it to the elevator in large quantities, and they have to take care of it. It is all right if you have a small amount of grain and can dry it on the grain bin floor. As a rule you cannot thresh grain that damp and have it accepted by the elevators.

We have been advocates of combines for a great many years, but we couldn't solve all of our climatic conditions. So we worked out this windrow method of harvesting and threshing. [Motion picture shows equipment in action.] These are four old ten-foot binders with extension carriers instead of binder heads on each, so that the cut grain of all four is deposited in one windrow. These conveyors are not exact multiples of the binder width, but are slightly less in length, so that the material from the several binders is deposited in offset, overlapping layers, forming a windrow of some width rather than one piled high. The binders of a train are connected by platforms or running boards whereby the attendant may move safely from one to another, and a signal cord extends from a bell in the tractor cab back through supporting loops on each binder to the rear of the train. This arrangement is used much like the bell cord of railway train or street car, one stroke of the bell being the signal for a stop and two bells meaning "go ahead."

No farmer likes to wait two weeks longer to cut his grain when he lives in a country where there is a weather hazard, particularly a hail hazard. We find we can cut grain two days earlier with this method than we can cut it to shock. It matures in the windrow and is just as safe from all weather hazards, even wind. It also eliminates all the unskilled labor. We have one skilled man on four binders.

This, we maintain, is applicable to small farms even more than to ourselves. We believe an outfit of three 8-ft. binders so equipped and a 12 or 16-ft. combine will pay for itself in one year on 640 acres of land, or in four years on 160 acres of land. There is nothing to get out of order; the binder head has been removed. As regards capital investment, there is a saving of approximately $125 on each binder by buying it without the knotter and binding mechanism, from which saving must be deducted only $5 or $10 for the materials with which to build the conveyor extension.

A saving in power arises from elimination of the binding and discharge functions of the binder, which, as every farmer knows, take a great deal of power. With the binder heads removed, eight horses or a small tractor can handle three 8-ft. machines.

When the grain is mature, the combine with a hayloader attachment picks it up from the windrow. We first used the loaders without a gleaning or pick-up attachment, and they were not satisfactory. Before we put the pick-up attachment on, we had a man following along picking up, and, of course, at three miles an hour he couldn't keep up.

Under our farming conditions a 24-ft. combine will handle 40 ft. in the windrows, almost doubling the capacity of the machine. A 16-ft. combine will handle 32 ft. and sometimes 40 ft. in the windrow. Of course, we have to adjust the speed of travel according to the yield of straw.

Our threshing crew, of course, is smaller than a shocking crew. We operated 16,000 acres of land in one farm this year and never had more than thirty-eight men on the job.

In this method we recommend an 8-ft. loader. They cost but very little more, and if the wind is blowing badly, the loader will still get all the grain. Six-foot loaders are hardly wide enough. Some of the companies make a gleaning attachment on the 6-ft. loader and not on the 8-ft., and vice versa. It is necessary to put a tight deck on the loader in order to keep the heads from falling through.

On the small combines, which have a high-lifting platform, it is not necessary to detach the cutter bar. The clamp is merely fastened on the rear and the loader hooked on it for grain which is unripened. And for cured grain, you can unhitch the loader in four or five minutes, drop the cutter bar, and combine in the regular way. Any combine that will clear 30 in. or so, will clear any windrow. We have used this windrow method in all kinds of grain. This year we used it exclusively on 7,000 acres of flax and saved our flax without any dockage for moisture content at all, and got 10 to 12 cents premium for it as a result. The advantage of the windrow method is that you never have more than a day or so of cut grain down. I think everyone will agree that the grain is safer, matures better, and keeps better, standing in its natural state, after the hail hazard is over, than in

any other way until it is in the bin. It is more thoroughly cured and has the proper moisture content.

This new method of farming, as we call it, from the standing grain to the grain box will cost about $4.50 an acre. By blanket tests this year we satisfied ourselves that the waste on the bundle carrier, the waste in the shock, the waste on the bundle racks, and the waste beyond the ordinary threshing machine, is each almost equal to the total waste from our new windrow and combine method.

Farming is like construction contract work. It is one of the severest kinds of contracting, with a time limit on it—a bonus if you get done in time and a penalty if you do not. I presume each year there are forty to sixty million bushels of grain damaged in northwestern Canada and the United States because they have neither the men nor the equipment to secure it safely.

There are many things for the engineer to do in agriculture, aside from just designing the machinery and making it efficient. He can do the same as he does on any other job, reduce the cost. You hear about our exportable surplus. That unwieldy surplus is always the farmer's problem and will be until he has the kind of cooperation from marketing agencies whereby he can market it in an orderly way. And until that is done, the only alternative is to do as the other manufacturers have done, namely, reduce the cost of production. That is the thing that is up to the agricultural engineer.

It is common knowledge that all other industries have increased their output per man many, many times. It has been done in agriculture, also, but not in the same ratio. And that is the thing the engineer can do.

I say without any fear of contradiction that the biggest opportunity today for the college graduate is in agricultural engineering. And that applies to farming in New York and Pennsylvania as well as in Montana and Wyoming. I never take a trip East and see the thousands of acres of abandoned farms, with their crooked fences and tumbled-down buildings, where they are within 10 cents of the market, while we are 60 cents from the market, but what I believe there are as big opportunities for farming in the East as in the West. I took a trip last week through Maryland and on down through Virginia and I saw literally thousands of acres of abandoned land, which I am satisfied could be made to produce most economically if operated by engineers and machinery.

The engineer will help the farmer to be more successful, so that he will be able to get credit. If the farmer had the credit he should have now from the proper sources, so he could buy cost-reducing machinery on time—instead of the machine companies having to carry him—he could own a combine, for instance, and operate his business more economically.

Aside from the help to the farmer, the engineer's other field is in connection with the manufacturing of farm machines. I know of some manufacturers who are spending a great deal of money experimenting. Some of them have had men on our job with machines and equipment as long as a year at a time, strictly at their own expense. That is progressiveness certainly. It is the sort of thing that is going to prevent machines getting on the market too soon.

We on our job feel we have had many things to overcome in the adaptation of machines to tractor hitches and power farming. Many of the failures of the farmer can be attributed in part to the type of machine which he has had to operate. Machines have been sold to farmers who have no mechanical knowledge whatsoever, which required adjustments within a thousandth of an inch. There are very few people who can think in thousandths of an inch unless they are technically trained. We find it of great advantage to send some of our best men to the short-courses which most of the colleges give in the winter time, just to learn to be accurate. We have lots of shop men who think they are accurate, but if you give them the ordinary stunt which is required in all engineering colleges, to take a piece of cast iron and make it one by three by four, perfectly square in every way and perfectly straight on all edges and sides, until they try to do it they have no conception of how hard it is.

That is what has to be done in engineering the farm. The agricultural college men who come to us are very valuable, and I am always trying to give full credit to the information we get from our agricultural colleges and our department of agriculture. But our experiences have proven to us that, after all, we have to add the close, accurate thinking and the calculating and estimating of the engineers.

DISCUSSION

H. B. JOSEPHSON: I would like to ask how you unload the grain wagons at the elevator?

MR. CAMPBELL: Every wagon has a sliding dump at the bottom. The wagon train is never unhitched. We drive the wagon over the scales, it is weighed, the bottom dump is pulled and the wagon unloaded, and the empty wagon weighed and driven off. We have to sweep out the corners, because we can't tip the wagon up, as the train is never unhitched.

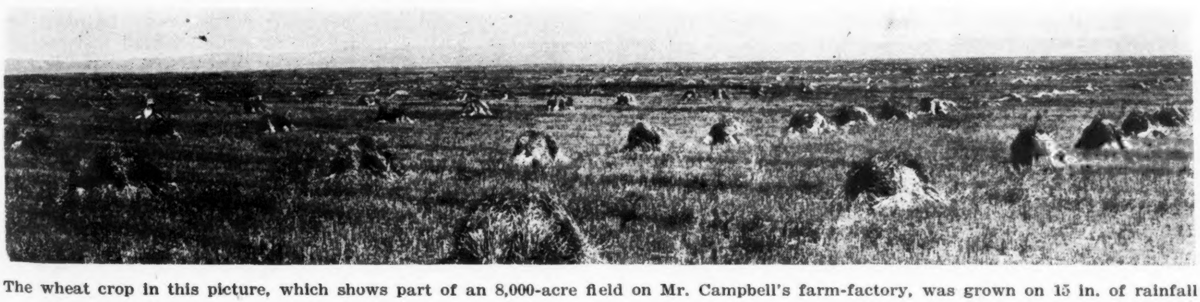
C. W. SMITH: Mr. Campbell mentioned he could cut the grain two days earlier than you can ordinarily with the combine. I am wondering how long it took the grain to cure on the ground in windrows under those circumstances.

MR. CAMPBELL: In much less time than it does in the shock. We cut about two days earlier than if we were going to shock it. Shocked grain as a general rule stands for a week to ten days, and if the custom machine doesn't get around, it stands for weeks. We allow it about seven days to dry, as a general rule, after we cut our first grain. But as the harvesting progresses, we can thresh it the next day or so.

Weeds, of course, are one of the big obstacles to the successful operation of the combine. We have found that weeds will dry out in about 24 hours. Weeds cause us more trouble than any other one thing in the operation of the combine, but if they are well dried out, the machine takes care of them.

A. P. YERKES: I would like to ask what the objection is to running 24 hours in field work, aside from the harvesting? Is there any reason why you can't work just as well at night and cut down the equipment investment and labor?

MR. CAMPBELL: We do do that a great deal of the time. Sometimes when the days are very long and we can get in 14 hours every day, we find it just about as economical to keep the one crew right on. And when the days get shorter and we can only get in 12 hours, then we put on a double shift. The objection to the double shift is the uncertainty of responsibility. The man who is on in the daytime is supposed to take up the bearings. He thinks it is foolish to take them up for the night man. When the night man comes on, he is fighting mad because the bearings aren't taken up, and he refuses to do it. And by morning the tractor is standing still.



The wheat crop in this picture, which shows part of an 8,000-acre field on Mr. Campbell's farm-factory, was grown on 15 in. of rainfall

H. W. RILEY: I think the nature of the work a man is doing would limit the length of the shift. For instance, in New York we have been experimenting to see what we can get out of power equipment by cultivating a two-row crop on hillsides. And our experiment seems to indicate the most efficient thing for us to do is to have two 8-hour shifts. We would have one man start just as early in the morning as possible and, after he has had a little of the heat of the day, have the second shift come on and finish the heat of the day and go on as long as he can. I understood you to say you ran the one shift throughout the entire day. Of course, you don't have the intensity of application as in our case where the man is jumping stones and dodging corn.

MR CAMPBELL: We have been afraid to start the eight-hour day. I presume it will come sooner or later. But, you see, eight months out of twelve is all our men work. The men are glad to take those shifts, and they are well paid. And in that way it requires fewer men and less operating expense. And as far as the strain is concerned, I don't suppose there is any man but who could stand it.

QUESTION: I would like to ask Mr. Campbell as to the overhauling of his equipment, just how that is done.

MR. CAMPBELL: We try to do it very thoroughly. We do it every winter. We commence just as soon as the ground freezes in the fall and keep at it until the frost goes out in the spring. We have to keep our managers and experts busy on that work in order to keep our organization together. One of our big problems is the turnover in men. And that is why we like to put in the long hours when we can, because our men figure it this way: They can work only eight months a year. And if they work an average of twelve hours for eight months, they are doing eight hours average over the whole year. They feel then that they can go to California, or to the big cities, and have a little time to themselves, and still put in as many hours as the average man. We work Sundays, holidays, and every other day. We never stop. And the men don't want to stop. They get paid by the mile too. If they put in an average of 18 miles a day, that means $1.80 bonus.

I forgot to ask the engineers to keep in mind a mileage recorder, one that need not be too delicately adjusted. Our mileage recorders are simply terrible. A good mile recorder is very, very essential in our business.

QUESTION: I would like to know what method is followed for maintaining your yields. And, also, if you spread the straw, what method is used to spread it?

MR. CAMPBELL: That is a hard one. We have tried two or three times to get a picture of a straw spreader working. We have gone slowly and done everything. But every time we have tried to do it, the spreader has gone to pieces before we got the picture taken.

We try to put the straw back onto the ground. We have tried to haul it diagonally along, and we have tried the rolling canvas. But the best method we have found is to let the straw fall out back of the machine as it is threshed. We find it does not fall in the same place another year.

Our first plowing is made four inches deep. We get a seedbed that fall suitable for winter wheat later on, and the first year we raise flax. Then we raise two crops without another plowing. We disk those two years. You can see that this straw, when it is chewed up and strewn over the ground, helps to conserve the moisture, just the same as a blanket, if thrown on a lawn, helps to conserve the moisture. It is the same as where you have an old straw pile; if you have noticed it, you will find that the plow will go right into the ground. Spreading the straw is the same thing.

For our second seeding, we seed only ten pounds per acre —sometimes not that much. With the shelled grain that is on the ground and what we seed, more would be too much. And where we have too many heads and no moisture to mature it, we do not get the yield. The Department of Agriculture tells us accurately how many days of wet weather we have and the amount of moisture. We check up carefully on our fields before we seed in the fall. We take the rain charts and go over them carefully. You can judge farming just as accurately as you can hydroelectric power, by using the Department of Agriculture's charts on rainfall, but you can't make the bankers believe that. If you don't believe it, try and borrow $8,000,000. They won't give you eight cents on agriculture. And why? Because we engineers haven't shown them what we can do. Some day we will convince them.

Now I must tell how we manage after the second crop. We let the fields grow up until the vegetation is a foot or eighteen inches high, and then we disk it in to conserve the moisture. We disk it in the fall to conserve the fall rains and the winter snow, and also the spring rains. By doing that we can plow a month longer the next year, and that means a lot. Plowing done in the dry months does not produce as well as plowing done in wet weather. The third year we plow down 12 or 18 inches of wheat, weeds, etc., and it makes good fertilizer. That seems to give our fields the right amount of nitrogen. We get the same protein content as we did the first year. We don't deplete the soil; we keep it up.

QUESTION: What do you do when you have a number of tractors plowing in the same field and one of them goes wrong?

MR. CAMPBELL: Go around it. The operators are all on a mileage basis and they won't stop. Nobody stops. The mileage basis has increased our average daily mileage from 14.7 to 18.1. And our average maintenance on a tractor used to be $380 a year, but since we charge for unnecessary breakages and it is deducted from the operator's bonus, the average maintenance is $97 a year.

Every five years we give our tractors a thorough overhauling. We get right down to the frame and take out all the loose bolts and overhaul everything. And the more I work with machinery, the more I am convinced I would rather have a drilled hole and a tight fitting machined bolt with a fine thread, than a hot rivet which didn't swell up and fill the hole and does not fit tightly. That is something to think about. The bolt has many advantages. You can tighten it if it comes loose.

QUESTION: I notice you use drill furrows deep and close together. How does that compare with a wider furrow?

MR. CAMPBELL: We have found objections to the wider furrows. If the furrows are quite far apart the weeds will grow up between them. The Russian thistles are particularly bad with wide furrows. The rows are not far enough apart to cultivate and it makes a very dirty crop. So we have gone back to the old six-inch disk drill, and then pack the soil.

G. W. IVERSON: There is one question I would like to ask Mr. Campbell. He has advocated the windrow method of harvesting the grain rather than using the combine as it is built at the present time. Do you believe we could do that in Illinois and some of the other states?

MR. CAMPBELL: Yes. I don't advocate the windrow method in lieu of the present method, but I do say you can start the harvest earlier, and offset the three main objections to the combine, which were mentioned at first. If the field is perfectly clean and dry and is uniformly ripe, there being no green spots, go ahead and combine it. But we have found out that that is seldom the case. Of course, if you live in a hail country—and practically all prairie country has a hail hazard—you must have a lot of courage to sit and wait ten days or two weeks, because any time a hail storm might come along and wipe out your entire crop. But still you want to use the combine. You can go ahead and cut and windrow the grain and use the combine in a few days to save it. Then you can use the combine in the usual way later on when the grain is ripe.

EDITOR'S NOTE: Mr. Campbell employed the new method in 1926 on 25,000 of his 38,000 acres of wheat, and on 7,000 acres of flax. The saving in direct operating cost was $50,000, and he estimates that under the unusually rainy conditions there were additional crop savings amounting to $25,000 on the wheat and $20,000 on the flax. It may be mentioned in this connection that Mr. Campbell is seeking a patent on the method, not with a view to commercializing it himself, but in order that the method may be available to all farmers without danger of it being patented and commercialized by someone else.

Design and Management of Individual Hog Houses*

By Ivan D. Wood[1]

THE work of developing an individual hog house which would be satisfactory under Nebraska conditions was started in 1911. At this time an A-shaped house, 7 by 7 ft. with 7 and 8-ft. roof boards was advocated. Later a house was developed which was 7 ft. wide and 8 ft. long with gable roof. The south slope of the roof was provided with hinged doors which could be lifted to admit sunshine. In 1922 a young farmer named Whisenand living near Harvard, Nebraska, attracted statewide attention with his success in raising and marketing stock hogs. An analysis of his success brought out two points—that he was following a scheme which permitted the young pigs to be raised on clean ground and that he was using a very successful individual hog house. The design of the individual hog house was being followed by farmers of the community with marked success.

The college of agriculture of the University of Nebraska built several of the houses and began the study of their management and design. Stock plans were made and sent out to several hundred farmers in various parts of the state. Later the farms where this house had been built were visited and results checked up. This work was done largely by M. B. Posson, extension animal husbandman, in connection with his work on hog lot sanitation and continued until 1926 when several thousand of the houses were in use. Suggestions of the various users were incorporated in the plans, tried out, and either retained or discarded. At the same time several of the houses had been under careful observation at the college farm with results being carefully noted. By the beginning of the year 1927 the plans of the original house had been changed considerably in light of the several years of observation and experiment. The "Nebraska Individual Hog House" is now in general use through the state, more than 15,000 having been constructed in the spring of 1927 and used with good results.

*Paper presented at the 21st annual meeting of the American Society of Agricultural Engineers, at University Farm, St. Paul, Minn., June, 1927. Contributed by the Committee on Building Design of the Structures Division.

[1]State extension agent in agricultural engineering, University of Nebraska. Mem. A.S.A.E.

Fig. 1. The Nebraska individual hog house. Note extreme height of door allowing sunshine to flood house during day

The Nebraska Individual Hog House. The house (Fig. 1) is A-shaped and has a width of 7 ft., a length of 6 ft. and is 4 ft. 8 in. high. The roof boards are 6 ft. in length, while the framing is of 2-by-4-in. material. At either end is a door 21 in. wide and 48 in. high. This door is firmly hinged but may be opened wide and hooked against the roof to prevent its destruction by wind or livestock. (Fig. 6 shows construction details.) A guard rail of 2-by-6-inch material is placed at the ends but is not necessary at the sides due to the flat slope of the roof which prevents the sow from crushing pigs in that location.

The ventilation is provided by extending the roof boards over the gable rafter 1¼ in. and nailing to them a triangular cover over the hole left above the door. The top of the door is stopped against a short 2-by-4-in. brace which also serves as a deflector to turn the air current upward before it enters the house. A ventilator of this design is used in each gable.

As originally built the roof boards were 12-in. barn boards and the ends were made of the same material. Wooden bats were used. Later developments showed the superiority of galvanized metal bats which do not give trouble when the wide barn boards shrink or swell. A piece of galvanized iron ridge-roll is used at the ridge and is placed after the bats are nailed on.

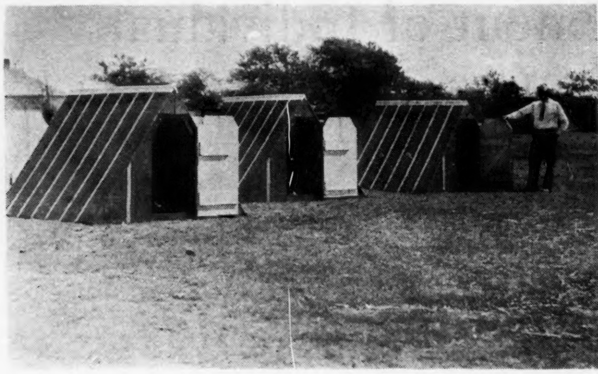
The frame material used is ordinarily of fir or white pine, the latter being preferable but more expensive in most sections. If possible the sills are made of creosote-treated pieces, as they come in contact with the wet ground and are subject to decay. The roof and ends are made of western white pine or Idaho white pine barn boards of 11½ or 12 in. width. An alternate construction consists of the use of flat grain fir flooring which is ordinarily clear and not much more expensive as the bats are omitted. The ridge roll and bats must be of galvanized iron and must be nailed on with galvanized nails. Common nails rust away rapidly allowing the bats to become loosened.

The floor plan size of 7 by 6 ft. with a gable height 4 ft. 8 in. has been found practical for young sows of weights up to 350 lbs. For aged sows the size is increased to 8 by 7 ft. with a gable height of 5 ft. 6 in. The cubic feet of air space in the smaller house is 97.86, and in the larger one it is 154. These figures are interesting when compared with the average gable roofed individual house with straight sides which has 240 cu. ft. capacity, or the average half monitor colony house which has about 538.5 cu. ft. capacity per sow. Even a low colony house of the Iowa type with a 4-ft. alleyway has a cubical capacity of 541 cu. ft. per sow, while with an 8 ft. alley it is increased to 678 cu. ft. per sow.

The low cubical capacity of the Nebraska individual house accounts for the fact that pigs may be farrowed in it in extremely cold weather and saved without difficulty. The ventilation is important, however, and when closed entirely litters have been suffocated. When constructed as shown in the plans no difficulty has been experienced in most adverse weather conditions while litters were suffering in colony houses not provided with artificial heat. It often happens in the colony house that only half of the pens contain litters, and under these conditions the air space per sow may be increased to more than 1100 ft., or more than eleven times as much as has been found practical in the individual house.

Observations of sow and litter in the house reveal that in cold weather the sow lies in the center with the young pigs in the bedding along the side. Due to the low flat roof of the Nebraska house, the sow cannot crowd the pigs out of this desirable condition nor can she lie on them at farrowing time or later. Guard rails along the ends are provided for safety.

Observations on the height of door reveals that practically all individual houses now in use are provided with low doors that cause the sow to lower her back when entering and



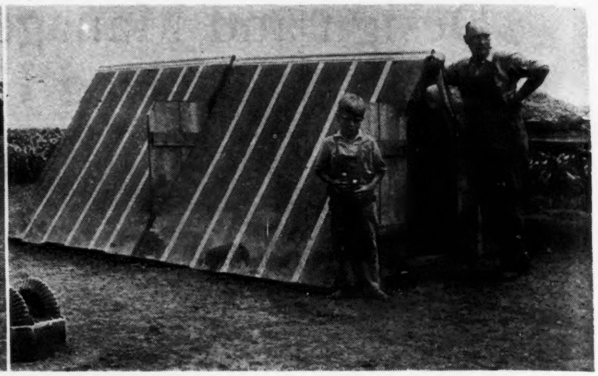


Fig. 2. (Left) Nebraska type individual hog houses lined up for farrowing use. Fig. 3. (Right) Houses lined up as summer quarters for stock hogs. The doors face slightly to the southeast

which do not allow sunlight to enter. With a 48-in. height, sunlight can flood the entire house during the day and plenty of ventilation is provided when the individual houses are lined up for use as sleeping quarters for stock hogs during the summer months. The bottom of the south door should swing clear of the ground by 2 in. to prevent dragging in the litter.

The amount of material used in the construction of the Nebraska individual house is 225 bd. ft., and the entire cost of materials exclusive of labor is about $12. Under ordinary conditions one man will construct two houses per day making the total cost about $14 each. Many of the lumber yards of the state are selling the house complete at a cost of from $13.50 to $15. The average cost of the permanent type colony house varies from $60 to $100 per sow. The interest charge on the more expensive types of houses would replace the individual house every five years.

It is very important that the individual house be painted immediately if the wide barn boards are used.

Development of Design for Factory Production. The proper use of the individual or two-sow hog house is the biggest factor in the hog lot sanitation campaign, later described.

It was decided in 1926 that the lumber dealers of the state could be made a strong link in the sanitation work if they could be induced to build, exhibit and sell at a reasonable price an approved design of individual hog house. In that year more than 5000 houses of the Nebraska type were sold by materials dealers and manufacturers of small farm equipment. Early returns for the year 1927 indicate a production of more than 15,000 houses and practically every farmer who has made a purchase has been told the story of sanitation and its importance to the swine industry.

The average number of individual houses purchased at one time by one individual is about ten. To haul these from the lumber yard to the farm requires from three to four trips, whereas the entire lot could be hauled at one trip if the houses are built in sections and "knocked down" for shipment. The knocked-down type is also advantageous to the yard or factory which makes shipments by freight.

By the development of mitre boxes and templates for correct sawing it was found possible to "ready-cut" all material including bats and ridge-roll permitting the houses to be sold in bundles of one house each. A later development consists of building the house in four sections which may be bolted together, after which it is necessary only to nail on the ridge-roll. For shipping, the four sections are laid flat and crated.

In the sectional type accurate templates are necessary to permit standardization of parts. Due to the fact that the 6-in. flooring runs true to size, it has been used for the ends and roof in preference to the barn boards which vary considerably in width.

The construction of the sectional or knock-down house does not vary greatly from the regular type. Fig. 7 shows the design which is being used by many lumber yards. The sides are built in one piece with the 2-by-4-in. members A, B and C in place. In this house the roofing is made of 1-by-6-in. flooring, tongued and grooved. The ends, including the rafters, door jams, sill pieces and siding are solidly nailed together and the door hung. Fig. 4 shows a slight modification of design which has proven to be very good. It will be noticed that the ridge piece is not used on any of knock-down houses, this being replaced by members A.

Relation of Housing to Sanitation. It is a matter of common knowledge that the conditions prevailing in the hog lot is responsible for a tremendous loss to the swine industry. Young pigs farrowed in unclean pens and allowed to run in the contaminated hog lot are infected with parasites and disease germs during the first few weeks of their life which later stunt growth or cause death.

The round worm alone is responsible for much of the

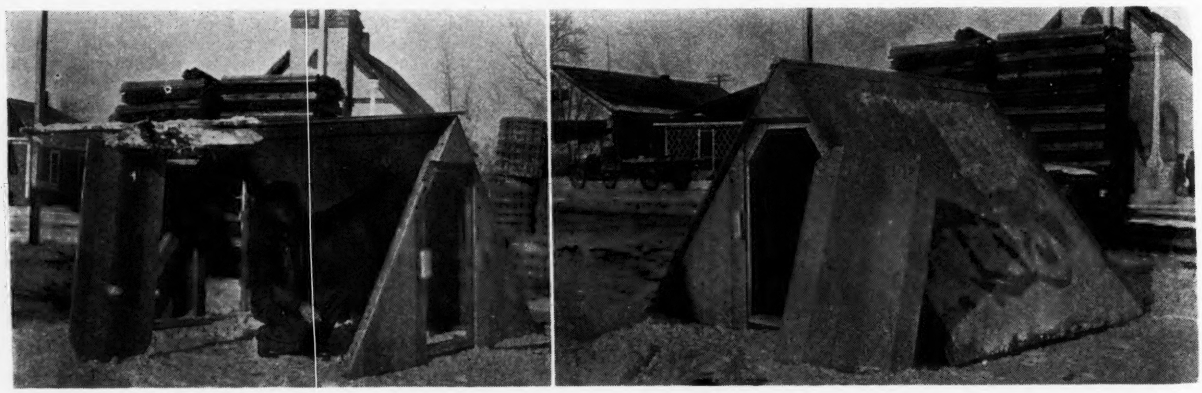


Fig. 4. Two views of the Nebraska hog house constructed in four sections by lumber dealers, to facilitate hauling several houses on trucks

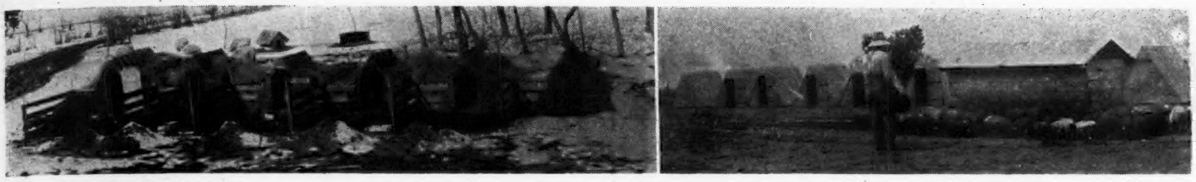


Fig. 5. (Left) A group of individual hog houses facing south at early farrowing time. Note panels for division of litters and straw banking for protection. (Right) Self-feeders used to lessen labor in feeding when using the individual house system

loss sustained. The eggs are picked up by the young pig very early in his career, probably from the udder of the sow in the first mouthful of milk ever taken. The worms hatch in the intestine, enter the blood stream, go to all parts of the body, and finally are strained out in the capillary circulation of the lungs. They puncture the capillary walls, enter the respiratory spaces, are coughed up, reswallowed to the intestines where they develop into full-grown individuals laying millions of eggs to pass off with the excreta. The puncturing of the lung gives rise to fever and so-called "thumps". At this stage many small pigs are laid on and killed by the sow; others are stunted. At the later stage, when the mature worms are in the intestine, great losses are sustained from stunted growth.

A disease known as pig typhoid is contracted from germs in the infected hog yard. This disease once in the herd will kill one year's profit in a few weeks. Death in the herd may be slight but the effects of the disease is such that no profitable gains may be expected.

Various necrotic conditions, such as "bull nose", "sore mouth", etc., may be traced directly to germs picked up in the hog lot.

The best veterinary authorities of the country agree that the only remedy for the above-mentioned troubles is sanitation carried out in a comprehensive way and the individual hog house plays an important part in the scheme.

One scheme consists of the thorough cleaning and disinfecting of the pens of the central hog house, careful cleaning of the sow before farrowing time, and keeping of the young pigs in the clean pen until they are two weeks of age, when they are moved out into individual or two-sow houses in clean pastures, pastures which have been plowed and have not been pastured by hogs for one season at least.

The second scheme and the one followed in many communities of the Middle West is gaining favor among swine producers everywhere. The sows are farrowed in the individual houses and the same individual houses are used through the entire year for summer quarters as well as winter. Each

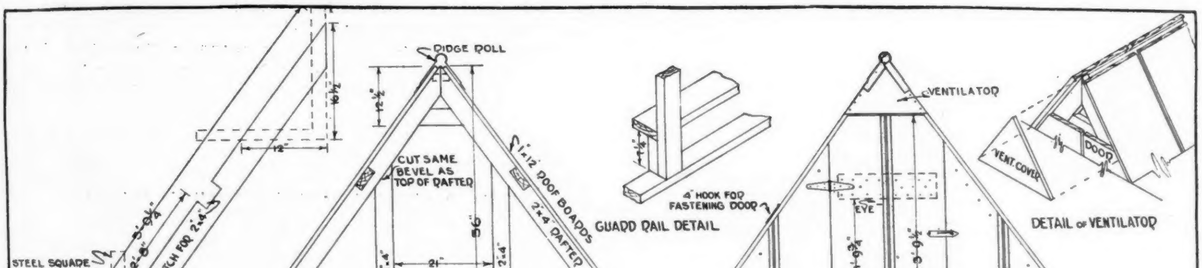


Fig. 6. Construction details of the Nebraska type individual hog house

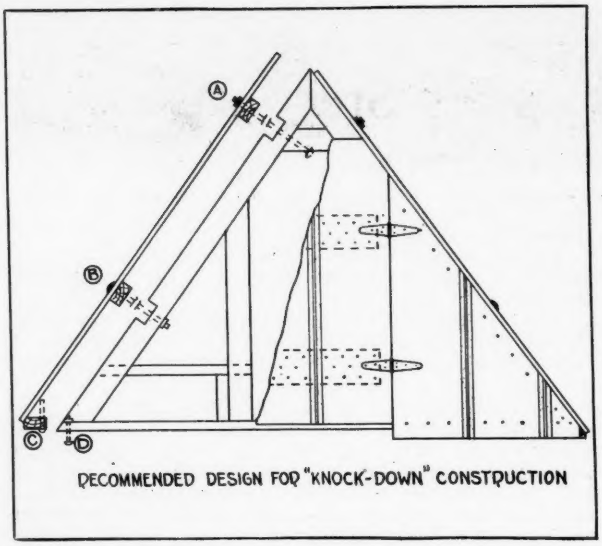


Fig. 7. Recommended design for knock-down construction of the Nebraska hog house

year the houses are moved to clean ground which is free from disease.

Management of Individual Hog Houses. Credit for the management of the swine herd when using the Nebraska individual hog house is due to M. B. Posson, state agent in animal husbandry, University of Nebraska. Mr. Posson has developed and proven by field use the practicability of the various arrangements of individual units described in the following paragraphs.

At farrowing time the Nebraska individual houses are lined up in batteries of ten or more facing the south and are banked between and behind with straw held in place with woven-wire fencing. This arrangement provides an excellent wind break, and experience proves that the south door may be left open except at night or on days when a raw south wind is blowing. The ventilator in the north gable may be partially closed during high north winds, but this is seldom necessary as the sow and litter warm the house sufficiently.

The houses are set 8 ft. on centers and pens formed in front of each house by attaching wooden panels of fencing for partitions. The ends of all pens are made by attaching woven-wire fencing to steel posts driven into the ground. After the litters are two weeks old the panels are removed and the houses scattered over the pasture. Little trouble is then experienced with mixing of litters or "robbing".

The location is important. The line of houses must be on well-drained ground which may be provided in flat fields by plowing a strip 18 to 20 ft. wide with open furrows at each side. Trenches may be dug between houses to remove drainage from the roof. Detached floors may be provided at the discretion of the owner and used as covering for sunshades during the summer. In the absence of floors, rooting may be prevented by setting the rows of houses on a strip of 60-in. woven-wire fencing.

A part of the herd of stock hogs may well use the individual houses for summer sleeping quarters after the sows are removed. In this arrangement two or three units are set end to end with all doors opened. The south door faces slightly to the southeast, thus preventing the entrance of the sun during the hot part of the day. The ventilation with this arrangement is excellent even in hottest weather.

When used for sleeping quarters for stock hogs or fall litters after weaning time, the houses are lined up in batteries of three or four with the gables running east and west, all doors being left open except the one on the extreme west and east. Each battery of three is joined to the next battery by opening the end doors of each and nailing them together temporarily. Several arrangements which have been found satisfactory are shown in the accompanying illustrations. The north and west sides of a line of houses are banked with straw held in position with woven wire.

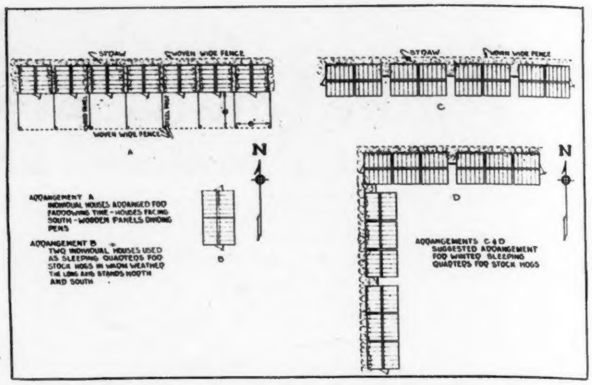


Fig. 8. Suggested arrangements of Nebraska individual hog houses for farrowing time and for summer and winter sleeping quarters for stock hogs

The feed problem in these detached farrowing quarters is readily solved by the use of self-feeders for both sows and pigs. The watering arrangements are not so easily made.

It is sometimes possible to locate a well in the center of a quarter section of land, to use each 40-acre field as a rotational unit and water each unit from a central supply tank. Most farmers using the sanitation plan use a tank wagon which may be filled at the well near the buildings and hauled to the farrowing lots where it is emptied into a second tank connected to self-waterers.

Tank wagons are now being manufactured which permit of the hogs walking up an incline and drinking from a waterer built in unit with the tank itself.

Results Obtained by a Comprehensive Sanitation Plan. The following table compiled by Mr. Posson of the Nebraska College of Agriculture shows the results of the work done in 1925:

In general it may be stated that the results over a three-year period show:

Table Showing 1925 Sanitation Results in Nebraska

	Farms on which pigs were farrowed in small houses and raised exclusively on clean ground	Farms on which pigs were farrowed in large house properly scalded then moved to clean ground and raised there	Farms on which only a part of the sanitation plan was followed out
Number of farms reporting	81	35	16
Average number of sows per farm	12.6	12.4	12.2
Average number of pigs raised per sow	6.5	6.2	5.2
Farrowed pigs raised—per cent	85	85	78
Farms feeding full ration—per cent	23	17	20
Farms feeding medium ration—per cent	40	45	43
Farms feeding light ration—per cent	37	38	37
Average number of runts per farm	0.9	2.3	2.5
Farms producing uniform pigs—per cent	85	65	50
Average weight of pigs raised at 6 months—lbs.	180	165	140
Pork produced per sow in 6 months—lbs.	1170	1023	770
Value at 9c of pork produced per sow	$105.30	$92.07	$69.30
Value at 9c of pork produced per farm	$1326.78	$1141.66	$845.46
Increased income for disease prevention	$481.32	$296.20	

Average number of sows kept per farm..............12
Average number runts raised on farms where no sanitation was practiced............... 4 per cent
Average number of runts raised under sanitary methods.........................0.9 per cent
Average weight of pigs at 6 months old on farms where no sanitation was practiced......140 lbs.
Average weight of pigs at 6 months old under sanitary methods ....180 lbs.
Average sized litter—no sanitation 5.2
Average sized litter—with sanitation...............6.7

Operating Characteristics of Electrically Heated Steam Type Dairy Sterilizers*

By A. W. Farrall[1] and B. D. Moses[2]

THE electric dairy sterilizer has been developed to the point where it is practical and economical. It has been in commercial use in California for about four years and there are at least five different companies now manufacturing this type of equipment.

Many questions have arisen relative to proper design, cost and efficiency of the electrical sterilizer and for this reason an extensive study has been made in the dairy industry laboratories of the University of California college of agriculture.

The same general method of procedure was followed as in the study of the oil-heated sterilizers reported in a previous article (AGRICULTURAL ENGINEERING, September, 1927; Vol. 8, No. 9). A certain standard load weighing 62.8 lbs. and consisting of one 10-gal. can, one 5-gal. milk can, one 3-gal. pail, one conductor head and one tubular cooler was used in all except certain special tests. Temperatures were measured by means of standard chemical thermometers inserted at the proper point through holes in the sterilizer. Electrical energy was measured by means of an indicating type wattmeter. Most of the tests were carried on in the laboratory under controlled conditions, but these were supplemented by two series of observations taken on actual dairy farms under regular operating conditions, in order to check laboratory operation with operation in the field. In addition to this a considerable number of manufacturers and dairymen in various parts of the state were interviewed regarding costs and practicability of the sterilizer.

The electric sterilizer as usually constructed consists of an enclosed tank in which a small amount of water is placed and an electric heating element of from 3 to 5-kw. capacity laid in or attached to the bottom in such a manner that the water surrounds the heating element. When current is turned on the water is heated and steam generated. The steam rises and envelopes the utensils to be sterilized which are contained in the tank, or in a separate chamber. The design of the sterilizer has considerable to do with the amount of water required since it must be such that the heating element is at all times submerged (with most of the present day elements).

Five general types of construction are being used at the present time. In Fig. 1 "A" shows the type using a float valve; "B" shows the type in which the element lies in a small trough in the bottom of the tank; "C" shows the thermo-syphon type in which the element is placed in a sloping tube attached to the bottom of the sterilizer and shoots steam into the sterilizing chamber from a slotted pipe; "D" shows an electric boiler arrangement which furnishes steam to a jet or to a sterilizing compartment, and "E" shows a reservoir type in which only a small amount of water is let into the sterilizer at a time and the supply automatically replenished as needed.

The more important data obtained are shown briefly in the accompanying curves and tables.

Effect of Amount of Water. Fig. 2 shows time and temperature characteristics of sterilizers using different amounts of water, the amount in each case being the minimum which should be used in practice. All sterilizers were of the same

*Third of a series of four articles on the characteristics of dairy equipment sterilizers, based on the results of investigations conducted at the University of California. The two previous articles of the series appeared in the June and September, 1927, issues of AGRICULTURAL ENGINEERING.

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[2]Assistant professor of agricultural engineering, University of California. Mem. A.S.A.E.

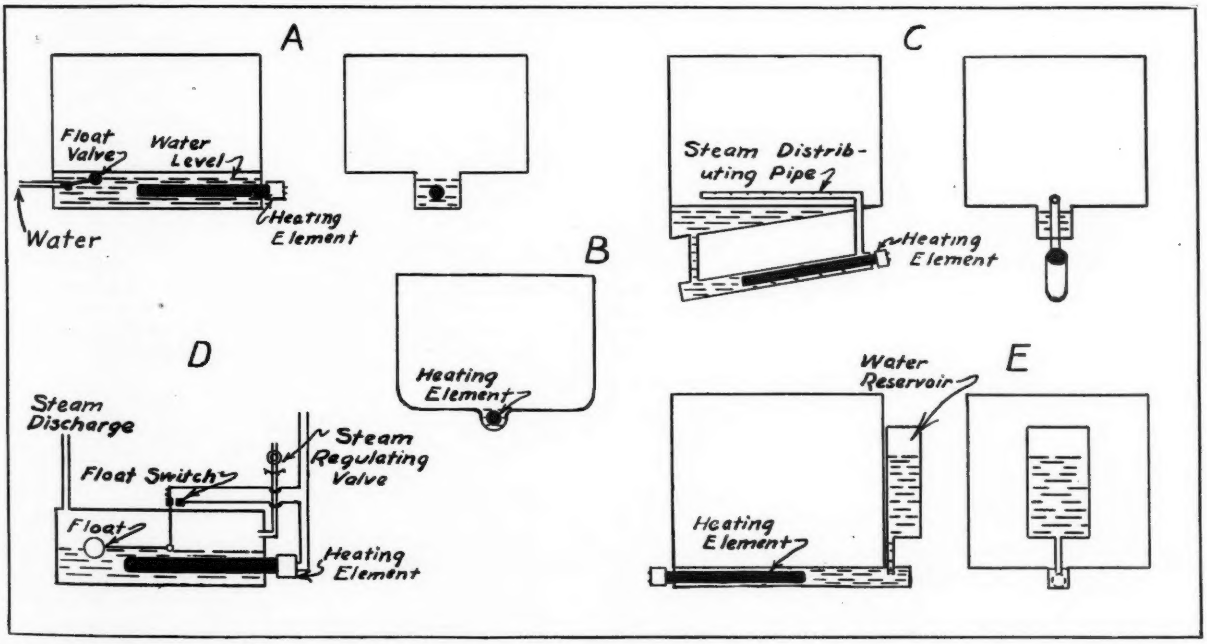

Fig. 1. These drawings show the construction of five general types of electric sterilizers. "A"—note the method of placing the heating element and water float; a wooden rack is provided just above the water level for supporting the utensils. "B"—the simplest type of electric dairy sterilizer, in which an immersion type element is laid in a groove in the bottom of the sterilizing chamber. "C"—a thermo-syphon heater in which the steam is forced out into the sterilizing chamber from a slotted pipe and the heating element is set well below the water line. "D"—an electric boiler arranged with a float switch for the purpose of turning off the current in case the water level becomes too low; steam is generated in the boiler and discharged through a pipe into an enclosed tank or a steam jet. "E"—a plain heating element with a small trough which is kept full of water from a reservoir which automatically feeds water into the trough as needed

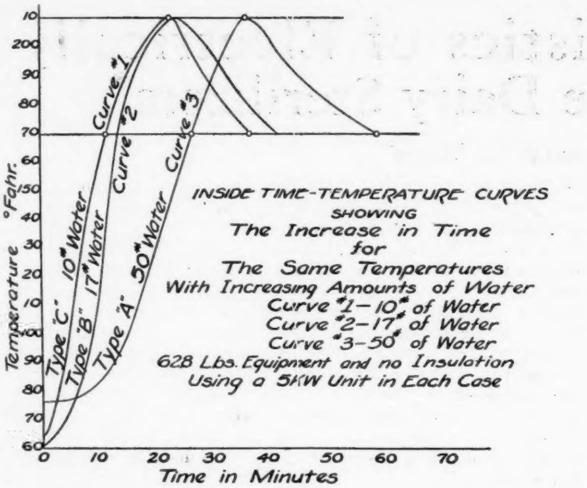

Fig. 2. Time and temperature characteristics of sterilizers using different amounts of water

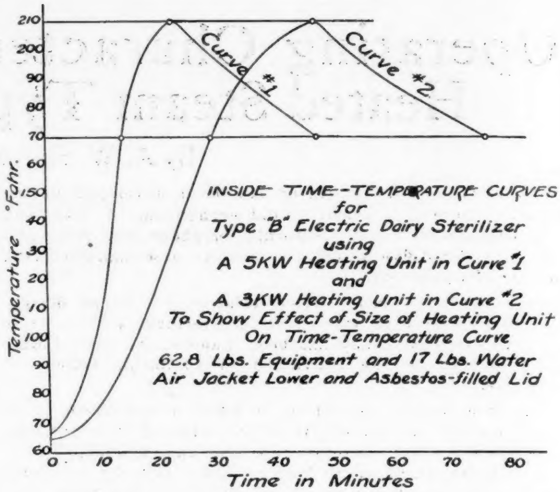

Fig. 3. Time and temperature curves of a sterilizer using 3 and 5-kw. heating elements under the same conditions

size and capacity. Results show that the sterilizer using only 10 lbs. of water heated up to the temperature of 170 deg. F. in 11.3 min. as compared to 14.1 min. for the one using 17 lbs. of water, and 26.5 min. for the one using 50 lbs. of water. It will be seen also that the time to reach 210 deg. was in about the same order. Another point worthy of note is that when the current is turned off, as it was in this case as soon as the temperature of 210 deg. was reached, the temperature immediately goes down. However, the large amount of water acts as a reservoir of heat and the time to cool from 210 to 170 deg. was 22.5 min. when 50 lbs. were used, 11.6 min. when 17 lbs. were used, and only 10.2 min. when 10 lbs. were used. It is significant that the time and energy required to heat to 170 deg. is wasted, as this temperature is not considered as being effective sterilization temperature. It is further significant that all the time above 170 deg. might be considered as being fairly effective sterilization. However, under severe conditions it is important to maintain the temperature above 210 deg. for 20 min. in order to obtain satisfactory results.

The total time for sterilizing is of importance to the busy dairyman and it is seen that approximately 14 min. in time are saved by using the 10 lbs. of water instead of 50 lbs.

Effect of Size of Heating Element. Fig. 3 shows the time and temperature curves of a four-can sterilizer using 3 and 5-kw. heating elements under the same conditions. From Lines 4 and 5 of Table I it is seen that the time required to reach 170 deg. F. was 13.4 min. for the 5-kw. unit as compared to 29.0 min. for the 3-kw. unit. Also, the time required to reach 210 deg. was 22.0 min. as compared to 46.7 min. One point worthy of note is that the rate of temperature rise decreased more rapidly as the temperature of 210 deg. was approached in the case of the 3-kw. heater than when using the 5-kw. heater. This point is of significance because it means that in cold weather the time required to reach 210 deg. will be very great with the small element. Also, that when the thermostat is used for turning off the power greater time above 170 deg. may be obtained with the 3-kw. heater than with the 5-kw. heater.

The water lost by evaporation is less when using the 3-kw. heater, but this is ordinarily of no importance when the heating element is turned off as soon as the temperature of 210 deg. is reached; there is considerable evaporation, however, when the current is left on for 20 min. longer.

From the practical standpoint the 5-kw. heater is preferable because it requires less time than the 3-kw. heater and furnishes an overload capacity which is needed in many parts of the country during the cold weather.

Effect of Insulation. Fig. 4 shows time and temperature curves for a four-can size sterilizer equipped with a 5-kw. heating element and with varying amounts of insulation. An analysis of the curves shows that the time for heating to 170 deg. F. was practically the same with the insulated and uninsulated sterilizer, being from 13.4 to 14.1 min. as shown in Lines 6, 7, 8 and 9 in Table I. The benefits of the insulation appear more noticeable, however, in the time required to reach 210 deg., for it is seen that the time was cut from 24.6 to 21.8 min. The benefits are still more apparent when the cooling curve is considered for it will be seen that the time for the best insulated sterilizer to cool off was 33.1 min. as compared to 11.6 min. when the power was shut off as soon as the temperature of 210 deg. was reached.

It was found that a 1-in. air space served as a satisfactory insulator since the sterilizer is operated for such a short time at each operation. The air space is more sanitary and more permanent, does not absorb water, and for these reasons is considered the proper type of insulation for small dairy sterilizers.

TABLE I. Operating Characteristics of Electrically Heated Dairy Sterilizers

Line	Temperature—deg.F. Room	Ster.	Water at start	Water—lb.	Ave. page time (min.) for sterilizer to reach 170°F.	210°F.	Cooling to 170°F.	Demand watts	Ave. kw.-hr. required to reach 210°F.	Average kw.-hr. req. to heat to 210°F. and hold for 20 min.	Load-lb. of equipment	Insulation of sterilizer
1	80.1	75.5	69.8	50	26.5	36.50	22.50	5736	3.48	5.392	62.8	Asbestos filled lid
2	60.5	60.7	63.0	17	14.1	24.60	11.60	5716	2.35	4.250	62.8	Plain galv. iron
3	69.0	65.3	65.0	10	11.3	22.50	10.20	5607	2.10	3.970	62.8	Plain galv. iron
4	66.8	64.7	63.0	17	29.0	46.70	24.90	2941	2.29	3.270	62.8	Asbes. filled lid, air jacket lower
5	68.0	66.6	64.9	17	13.5	22.00	24.90	5625	2.07	3.945	62.8	Asbes. filled lid, air jacket lower
6	60.5	60.7	63.0	17	14.1	24.60	11.60	5716	2.35	4.255	62.8	Plain galv.
7	68.6	68.0	66.3	17	13.5	23.80	17.60	5614	2.23	4.101	62.8	Plain lid, air space lower
8	68.0	66.6	64.9	17	13.4	22.00	24.90	5625	2.07	3.945	62.8	Asbes. filled lid, plain lower
9	62.2	61.2	61.3	17	13.8	21.80	33.10	5557	2.02	3.872	62.8	Air jacket all over
10	70.8	68.8	66.8	17	29.2	54.10	17.60	2883	2.60	3.561	62.8	Plain lid, air space lower
11	66.8	64.7	63.0	17	29.0	46.70	29.40	2941	2.29	3.270	62.8	Asbes. filled lid, air space lower
12	44.0	54.5	62.0	17	14.7	24.86	14.30	5323	2.20	3.974	62.8	Plain lid, air space lower
13	43.7	52.5	62.5	17	15.4	24.17	22.88	5313.5	2.12	3.891	62.8	Asbes. filled lid, air space lower
14	68.0	66.6	64.9	17	13.4	22.00	24.90	5625	2.07	3.945	62.8	Asbes. filled lid, plain lower

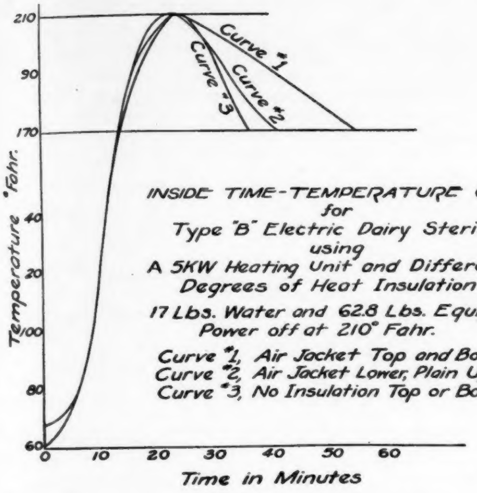

Fig. 4. Time and temperature curves for a sterilizer equipped with a 5-kw. heating element and with varying amounts of insulation

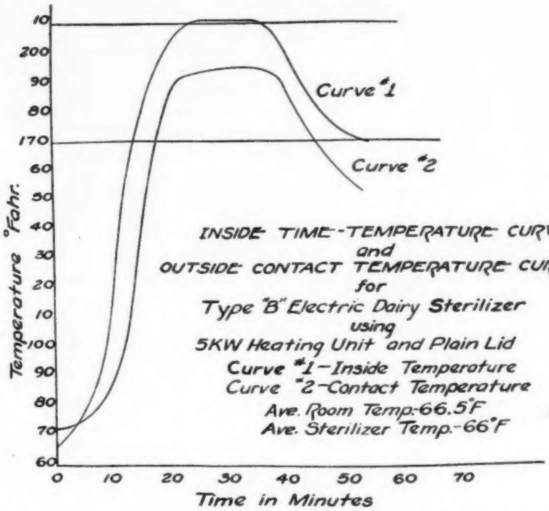

Fig. 5. Comparison of inside and outside temperatures of an uninsulated sterilizer

Insulation is especially desirable where a 3-kw. unit is used, as shown in Lines 10 and 11. The time for heating to 210 deg. was decreased from 54.1 to 46.7 min. by merely insulating the cover or upper part, the lower half being insulated with an air space.

The energy used in bringing the sterilizer to a temperature of 210 deg. F. was 2.02 kw.-hr. for the well-insulated sterilizer as compared to 2.35 kw.-hr. for the uninsulated one, using 5-kw. heaters. The energy used by the 3-kw. heater was decreased from 2.60 to 2.29 kw.-hr. per batch by merely insulating the cover or upper half of the sterilizer.

The rate of evaporation or loss of water is increased considerably by the use of insulation, especially if the current is left on after the temperature of 210 deg. has been reached. The principal effect of good insulation is that the sterilizer retains the heat after the power is turned off, providing that the cover is left on. This makes possible the use of a smaller heating element after the sterilizing temperature is once attained, or allows part of the sterilizing to be done by heat remaining after the power has been turned off. It is questionable whether the latter practice is desirable, however, since the utensils should be removed from the sterilizer and placed in a dry place where they will thoroughly dry off from the heat remaining in them; this last is desirable from the standpoint of prevention of rust and of bacterial growth which always takes place in the presence of moisture and warmth It is undoubtedly desirable to insulate the sterilizer tank if it is to be used in a cold climate or in a place subject to strong air currents, and where a small heating element is used.

The effect of insulation is apparent in Figs. 5 and 6 in which the outside temperature of the metal housing is compared to the inside sterilizer temperature. Fig. 5 shows that with the uninsulated sterilizer the outside contact temperature was within about 20 deg. F. of the inside temperature; Fig. 6 shows that with the sterilizer insulated with ½-inch asbestos the outside temperature was 75 deg. lower than the inside temperature. It is readily seen that the amount of heat radiated is much less in the case of the insulated sterilizer.

Effect of Cold Room Temperatures. The effect of low temperatures upon the operating characteristics of the sterilizer are shown in Lines 12, 13 and 14 of Table I. Line 14 shows results obtained at normal room temperature with asbestos-filled lid, and Line 13 shows results obtained at a room temperature of 43.7 deg. F. It was found that 2.17 min. longer were required to reach a temperature of 210 deg. at 43.7 deg. temperature than at 66.7 deg. Comparison of Lines 12 and 13 shows that the time required for heating the plain sterilizer with uninsulated cover was only 0.7 min. longer than when an insulated cover was used. It is recognized, however, that in many localities temperatures much lower than 40 deg. are encountered, as well as draughts, and under such conditions a much greater difference would be found.

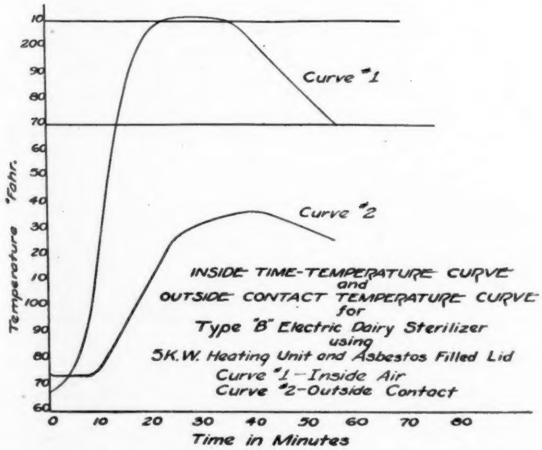

Fig. 6. Comparison of inside and outside temperatures of an insulated sterilizer

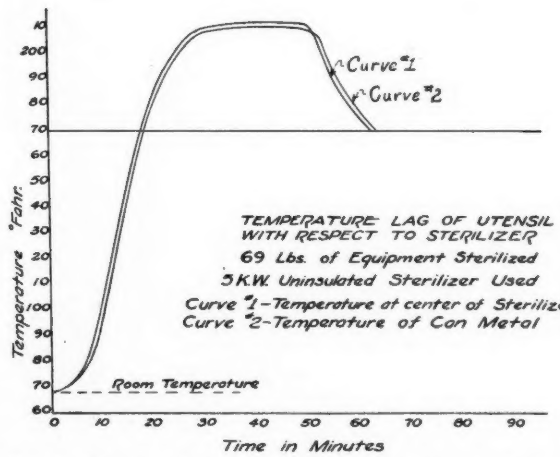

Fig. 7. Time and temperature curves for sterilizer and utensils sterilized

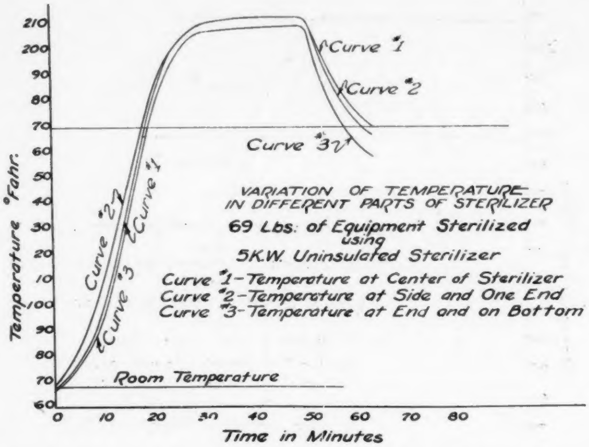

Fig. 8. Time and temperature curves from readings in three different parts of the sterilizer

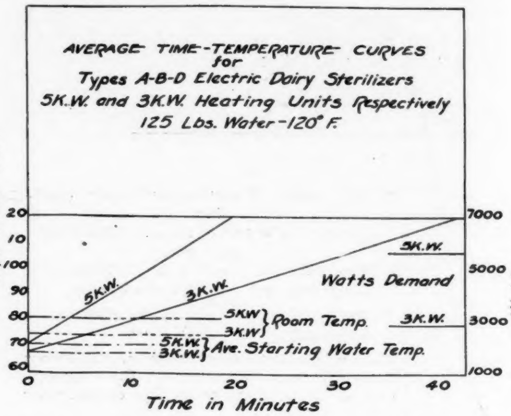

Fig. 9. Time and temperature curves obtained in heating water with 5 and 3-kw. heating elements

Temperature Lag of Utensils Sterilized. Fig. 7 shows time and temperature curves for the sterilizer and the utensils sterilized. The sterilizer temperature was measured at the center of the top and the utensil temperature was obtained by placing a chemical thermometer in an oil well well soldered onto the can near the top and projecting through to the outside. It is apparent that there is a certain lag of the can temperature behind the sterilizer temperature but this is not great, being a maximum of 7 deg. F. in the tests conducted. It is, of course, true that the more quickly the sterilizer temperature is brought up, the greater the lag will be. The can holds its heat and is at a higher temperature than the sterilizer after the power has been turned off providing the lid is left on the sterilizer.

Uniformity of Temperature Within the Sterilizer. Fig. 8 shows time and temperature curves plotted from readings taken in three different parts of the sterilizer. Curve No. 1 represents the temperature taken at the center of the sterilizer. Curve No. 2 shows the temperature taken at one side and near the front end. Curve No. 3 shows the temperature at one end and near the bottom of the sterilizer. All temperatures were taken with similar chemical thermometers inserted through holes made in the side of a sterilizer with plain uninsulated cover.

It will be noted that during the heating period the difference in temperature in the various parts was only about 12 deg. F., while after reaching the temperature of 210 deg. the variation was only about 3 deg. and during cooling, with the cover on and power off, the temperature tended to stratify and the bottom cooled off more rapidly than the top. The above tests were made with a load of 69 lbs. of equipment. The difference in temperature was found to be less when no equipment was used in the sterilizer. A good circulation of steam is necessary if uniformity of temperature is to be obtained.

Bacterial Reduction. Table II gives results of bacterial reduction tests and shows that the efficiency is quite satisfactory, comparing favorably with that of the oil heated sterilizer. In all tests conditions were purposely made quite severe, the cans being either taken from the regular milk route or contaminated by washing with milk that was known to be of high bacteria content. Cans were only rinsed out, rather than thoroughly washed, and then placed in the sterilizer. Complete sterilization is not practicable on the farm on account of high costs and the time required, but it is considered that the results obtained in this series of tests are quite satisfactory. The utensils should be stored in a clean, dry place after sterilizing and cooled immediately in order to prevent the growth of bacteria.

TABLE II. Bacterial Reduction Tests Electrically Heated Dairy Sterilizers

Test No.	Bacteria per cc. of water used in making wash: Before sterilizing	After sterilizing	Max. tem. of sterilizer —deg. F.	Time of sterilization
1	1260	37.0	210	Brought to 210°F.
2	1260	42.0	210	Brought to 210°F.
3	1,000,000 +	34.0	212	Held 20 min.
4	1,000,000 +	2.5	212	Held 20 min.
5	1,000,000 +	8.5	212	Held 20 min.

NOTE: Observations of the condition of the cans used in these tests showed slight rust.

Water Heating. One of the auxiliary uses of dairy sterilizers is to heat water for purposes of washing utensils where no other means is at hand. On this account electric sterilizers should be made so that they can be used for heating water if desired. It is usually considered that the average small dairy of twenty to forty cows should have about 10 to 15 gal. of water at 120 deg. F. for this purpose.

Fig. 9 shows the time and temperature curves obtained in heating water with 5 and 3-kw. heating elements, respectively, with an ordinary dairy farm sterilizer. It was found that 125 lbs. of water, or approximately 15 gal., could be heated to 120 deg. in 19 and 40 min., respectively, and at an energy consumption of 1.9 and 2.05 kw.-hr., respectively, as shown in Table III.

It is of interest to note that the 5-kw. outfit was slightly more efficient than the 3-kw. outfit, no doubt due to the radiation loss being over a shorter period of time with the former.

Controls and Connections. Various means have been tried for controlling the electrically heated dairy sterilizer. Some are turned on and off by hand, some by thermostats and others by time switches. It is thought that some sort of automatic control is desirable as that should be one of the advantages of the electrically operated outfit. The ideal combination would be a combination of a thermostat and time switch which would bring the sterilizer up to a certain temperature, hold it for the required length of time and then turn off the power. It would also be desirable to draw off the water and raise the lid of the sterilizer at the end of the period. To date, due to the cost of the necessary equipment, it has been held down to either straight thermostatic or time-switch control. Some difficulty has been experienced with obtaining thermostats which would last and give satisfactory service. Good results seem to be obtained from time clocks. These operate quite successfully providing they are changed to care for larger loads or cooler weather. However, if the sterilizing operation is carried on with a considerable

TABLE III. Water Heating Data

Line	Temperature—deg. F.: Room	Start water	Final water	Weight of water —lbs.	Ave. time to heat to 120° F. —min.	Ave. watts demand	Ave. kw.-hr. used	Per cent of heat utilized
1	81.5	71.5	120	125	20.0	5721	1.90	94.5
2	75.0	68.0	120	125	42.0	2930	2.05	93.0

factor of safety, this changing is not necessary very often.

Some sterilizers have been equipped with small float valves which automatically maintain the proper amount of water in the sterilizer at all times. One advantage of the thermostat or time clock is that they prevent burning out of the heating element due to evaporation of too much of the water and consequent uncovering of the element in case the operator neglects to turn off the power.

Cost of Operation. The cost of operation of the electric dairy sterilizer is low providing it is well designed, operated according to best practice, and if the power rate is not high. Table I shows results of a larger number of tests under controlled laboratory conditions. It will be seen that the energy consumed varies from 2.02 to 3.48 kw.-hr. if current is turned off as soon as a temperature of 210 deg. F. is reached, and 3.27 to 5.39 kw.-hr. if held for 20 min. at 210 deg. Results show that for most economical operation the sterilizer should be of small water capacity and well insulated. It should also be large enough to hold any of the farmer's equipment. It is of little use to sterilize a part and leave out a cooler or other piece of equipment which is too large to go into the sterilizer. The equipment may be sterilized in several batches if desired.

CONCLUSIONS

1. The electric sterilizer should be compact and made of material with low specific heat.
2. It should use the minimum amount of water and still not be subject to burning out of the element.
3. The most satisfactory size heater for a four-can size sterilizer is a 5-kw. unit, as shown in Figs. 3 and 9.
4. The sterilizer tank should be well insulated with a sanitary, double-wall type air space insulation for best results in places where low temperatures or cool air currents are encountered.
5. The temperature lag of the utensils with respect to the sterilizer temperature is not great in the small four-can size sterilizer; this lag varies directly as the rate of heating.
6. The temperature difference in various parts of the sterilizer is not great.
7. Satisfactory bacterial reduction is obtainable with electric dairy sterilizers provided they are brought to 210 deg. F. and held for 20 min. Good results may often be obtained by holding for a shorter time.
8. The dairy farm sterilizer should be able to heat at least sufficient water for washing purposes.
9. The use of an automatic control is advisable in many places. It should turn off the power when the sterilizing operation is finished.
10. Heating elements should be made of low wattage per unit area, in order that they will not burn out if the water is boiled away.
11. The electric dairy sterilizer is a satisfactory piece of equipment and will give satisfactory service if properly designed and operated.

An Applied Farm Mechanics Demonstration

By E. G. McKibben[1]

THE agricultural engineering division of the University of California presented a unique demonstration in applied mechanics as their contribution to the program developed by the college of agriculture as an educational-entertainment feature of the Annual Boys Agricultural Club Camp at Davis.

The boys were seated on temporary outdoor bleachers. The head of the agricultural engineering division gave a ten-minute discussion of the relationship between "force," "distance," "work," "time" and "power." This discussion was followed by a fifteen-minute practical demonstration, thus fixing definitely in the minds of the boys the connection between the fundamental principles of theoretical mechanics and the everyday problems of agriculture.

Fig. 1 shows the club leader seating the boys preparatory to introducing the speaker.

In Fig. 2 the head of the agricultural engineering division, who has finished his brief discussion of "force," "distance," "work," "time," and "power," is conducting, with the aid of an assistant, a homely but effective demonstration of the practical relationship of these factors. The simple apparatus used consisted of three kegs of nails of equal weight, a shop bench, an inclined plank, an automobile crane, a man to lift one keg onto the table, a large boy to roll one keg up the plank, a small boy to raise one keg with the crane, a yardstick to measure the distance, and a stop watch to record the time required for each operation. Similar apparatus is available in any high school farm mechanics shop.

Figs. 3 and 4 show another application of the same idea to the ever-present agricultural problem of tillage. Fig. 3 shows one small boy pulling a two-bottom plow by means of a chain block. Fig. 4 shows twelve boys pulling the same plow in the same soil by means of a direct hitch.

In order to show the pull being developed by a tractor on a scale large enough to be seen by all spectators the tug meter shown in Fig. 5 was built by mounting a simple indicating traction dynamometer on a cultivator frame and connecting the dynamometer to the amplified scale pointer by means of suitable levers. Fig. 6 shows the method used to demonstrate the relationship between a tractor's weight and its tractive ability.

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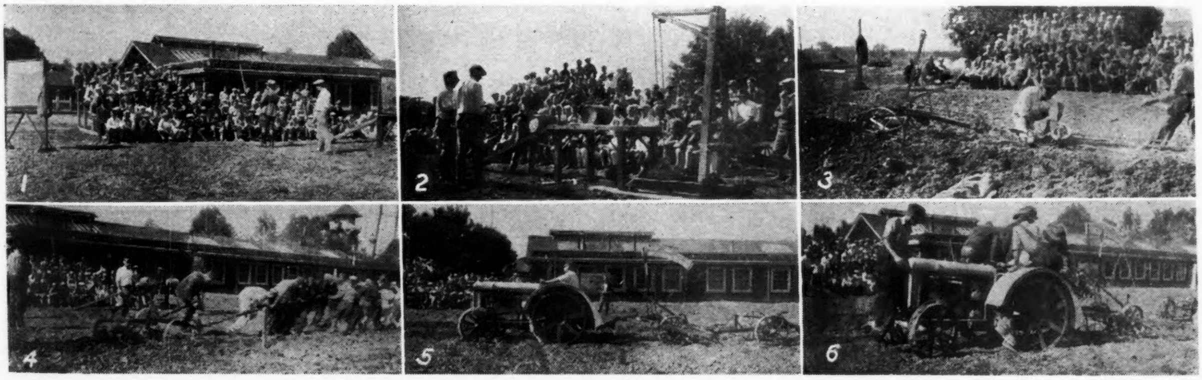


Fig. 1. Club leader seating the boys preparatory to introducing the speaker. Fig. 2. Demonstrating the relationship between "force," "distance," "work," "time" and "power." Fig. 3. One boy pulling plow a distance of one foot with a chain block: large force but slow speed. Fig. 4. Twelve boys pulling plow a distance of one foot with direct hitch; approximately same force, distance and work as in (3), but higher speed and, therefore, greater power. Fig. 5. Tugmeter developed for purpose of showing on a large scale the pull developed by a tractor. Fig. 6. Demonstrating the relationship between weight and tractive ability

1927 Corn Borer Clean-up Campaign a Success

THAT the 1927 corn borer clean-up campaign has been a success is the outstanding conclusion to be reached as a result of the three-day conference held September 21, 22, and 23, under the auspices of the International Corn Borer Organization.

Starting at Toledo, the headquarters of the federal government clean-up forces, the first two days of the conference were devoted to field tours, during which fields and laboratories in Ohio, Michigan and Ontario were inspected, including a demonstration of low-cutting attachments for corn binders and field ensilage harvesters.

In the neighborhood of two hundred people attended the conference, including entomologists, agronomists, rural economists, agricultural engineers, farm equipment manufacturers, farmers, dealers, farm paper representatives, and quite an array of government officials.

To sum up briefly, a statement issued by the U. S. Department of Agriculture points out that as a result of recent field surveys of 743 townships in the heavily infested states, the ten-million-dollar spring campaign against the European corn borer has somewhat retarded the corn borer's American invasion. A census of the corn borer population determined by actual count in the field during the month previous to the conference showed that at that time there was an average of 13 borers per 100 stalks in the campaign area, as compared with an average of 8 borers per 100 stalks last year and 2 borers per 100 stalks in 1925. Dr. A. F. Woods, director of research in the U. S. Department of Agriculture, explained that though this means an increase of 50 per cent in borer population this year, it compares favorably with the increases of 400 per cent in borer population registered in 1926, when there was no control campaign, and that had there been no campaign this spring, judging by the increase in 1926, we might now find 32 instead of 13 borers per 100 stalks.

The session of the conference on Friday, September 23, was devoted principally to business matters of interest to those concerned with the campaign to control the corn borer, especially to discussing the progress that had been made and to consider plans for continued prosecution of the fight against the borer. The session was presided over by C. G. Woodbury, director of raw products research of the National Canners Association, who is a member of the International Corn Borer Organization. The session was opened by a report of the secretary of the International Corn Borer Organization, C. B. Truax, director of the department of agriculture of Ohio. He was followed by Dr. A. F. Woods, of the U. S. Department of Agriculture, who outlined what the ten-million-dollar appropriation for corn borer control had been spent for. Dr. Woods explained that the figures he gave were unofficial but that expressed in round numbers they were as follows: For mechanical equipment of all kinds and supplies, $3,200,000; for publicity and educational effort, $300,000; for general expenses, $1,500,000; for compensation to farmers for cleaning up fields, $4,200,000. What is left of the $10,000,000 will be used for clean-up work this fall and next spring.

It was particularly gratifying to those agricultural engineers who attended the conference to note the place and importance placed upon agricultural engineering in the corn borer control efforts by those active in the work. Dr. Woods, particularly, pointed out that there is a big program ahead of research in the agricultural-engineering phases of the corn borer problem, not alone in the special machinery needed to fight the pest, but engineering problems in general. Assistant Secretary of Agriculture Dunlap stated that he had a great deal of faith in the engineers to bring out machinery to handle the corn crop most effectively and combat the borer. He believes this is one of the biggest problems and stated that in his opinion the engineers would do a great work in that direction which would lead to ultimate success in keeping the corn borer under control. Secretary Dunlap is convinced that all the time and funds necessary should be given to a research program on the corn borer. He feels it is essential also to conduct an educational campaign to get the cooperation of farmers, and that farmers who cooperate in the clean-up work should receive a larger compensation for their efforts.

All speakers at the third-day session were unstinting in their praise of the splendid cooperation between all groups engaged in combating the corn borer. Dr. Marlatt, of the U.S.D.A. Bureau of Entomology, stated that, in his opinion, the success of the campaign was due primarily to cooperation.

On September 22 a joint committee representing the American Society of Economic Entomologists, the American Society of Agronomists, and the American Society of Agricultural Engineers spent the entire day in the preparation of a report, which was presented to the conference at the third day's session by L. E. Call, dean of agriculture of Kansas State Agricultural College and chairman of the joint committee. The report endorsed the efforts that had been made in behalf of corn borer control and highly commended those responsible for the control work, including the splendid cooperation of farmers. The report presented the opinion that the corn borer cannot be eradicated or prevented from spreading, but that control measures have contributed to a very effective control of the pest. It concluded with more than twenty definite recommendations relative to the various phases of future control work. The report was enthusiastically received and unanimously approved by the conference.

Representatives from Canada, including the province of Ontario and the Canadian department of agriculture, reported on the progress of clean-up work in Ontario and the Canadian situation in general.

L. H. Worthley, "field marshall" of the government control forces, briefly reviewed the scouting work that had been done the past season to discover new infestations of the corn borer and the probable spread of the pest during the present year.

Dr. D. J. Caffrey, of the U.S.D.A. Bureau of Entomology, explained the details of arriving at the percentage or extent of corn borer infestation.

C. O. Reed, in charge of the engineering phases of the corn borer campaign, presented a summary of the work in corn borer control by mechanical means. He pointed out that the development of control by machinery is divided into three phases: (1) Adaptation of present machines with suitable attachments, (2) new machines for present needs, and (3) new machines for future needs.

Mr. Reed stated that the stubble beater is a very important machine and with the improvements which are being made to increase its efficiency, it will become increasingly important, particularly under certain conditions. He also emphasized the great importance of plows as a factor in the control work by mechanical means. Properly designed rakes to facilitate cleaning up the fields is considered by Mr. Reed a particularly important need. He also outlined the importance of burners and pointed out that attachments for corn pickers have great promise.

Mr. Reed paid a very high tribute to farm equipment manufacturers for their cooperation in the development of suitable machinery. He also announced that an elaborate program of research in mechanical control is being worked out, which comprehends the cooperation of federal and state divisions of agricultural engineering, manufacturers, and the American Society of Agricultural Engineers.

General satisfaction was expressed by those in attendance at the conference with the results of the corn borer clean-up work. The results of the season's efforts that were set forth at this conference stand as a splendid tribute to those who have been active in the control work. It is anticipated that an extension of the control work, including an elaborate program of research, will be backed up by the necessary support from the federal and state governments.

EDITOR'S NOTE: The report of the joint committee representing the American Association of Economic Entomologists, the American Society of Agronomists, and the American Society of Agricultural Engineers mentioned above will appear in the November issue of AGRICULTURAL ENGINEERING.

Latest Developments in the Motorization of Corn Production*

By G. W. McCuen[1]

NEVER in the history of agriculture has there been so much interest focused upon one thing as there is at present centered upon America's principal source of food —the corn crop. It may be said that two things are quite responsible for this interest: The menacing invasion of the European corn borer and the prevailing low prices for the crop.

It will not be necessary to dwell on the menace of the corn borer to the corn crop, for we are all now quite familiar with the damage that has been done. It is my sincere belief that in order to grow corn in the face of competition with the borer, the uncertainty of the seasons, the fluctuation of prices, the use of machinery and power will be paramount. If early maturing varieties of corn are developed which will be good producers and can be planted late in order to avoid possible infestation, machinery of proper design will play an important role, for with late planting the processes of planting and cultivating cannot be delayed and a good crop assured. Time will be the essence of good farming and timely caring for the crop cannot be had with the farm equipment of yesterday.

In nearly every paper we read of some sort of a solution for the corn grower's plight, of how much the farmers are losing by receiving only a part of what it costs to produce the crop. Also we find that one man may produce at a ridiculously low cost while many produce at an equally ridiculously high cost. We find the former very much in the minority.

There seems to be a general awakening in process among farmers of the corn belt to the fact that they must do something for themselves. Corn has cost them too much to produce and since the control of the cost of production lies largely in their own hands, they are considering ways and means of cutting down the man-hours labor, this being one of the costly items in the production of corn.

It is then quite logical to think of modern machinery as a means of reducing the production costs. One writer recently pointed out that cost of production no matter how low is not the panacea. That is true. Weather conditions must be considered, and a deficiency of rainfall in July would spell disaster to the corn yield. The production costs would, however, remain the same for a poor crop as it would for a good crop. Therefore, we must not lose sight of the fact that even though the crop is poor, and we have only a small labor cost involved, the loss is not so great as where the labor costs nearly equal the net returns.

It has been said by some, who do not think in terms of modernized farming, that I am too much of a power-farming enthusiast, but it has been my pleasure to see what some called an idle dream come to full realization at Ohio State University. Five years ago when our study of the motorization of the corn crop was started, the only man in authority to give encouragement to such a project was Dean Alfred Vivian, of our college of agriculture. It was his vision that made it possible to start the work in the face of opposition of those who thought that the kind of farming being practiced in Ohio, especially at the university, was on quite a high plane of efficiency at that time. It was their hindsight and not their foresight that was bothering them. Tomorrow's agriculture was being gaged by the practices of yesterday.

After two years of work on the project those who were most critical saw that a great amount of work was being accomplished with a small expenditure of human effort. If it were possible to do so much work with only one man, why could not the practice be made general for the whole University farm. Some very radical changes were made in the university's farm equipment, which today is quite modern.

Two seasons ago a motor cultivator was added to the complement of university farm tools. I shall not attempt to enumerate the things the farm mechanic does with this piece of equipment, for they are many. The motor cultivator has made it possible to get over with little effort, what, in former years, were almost insurmountable peak loads.

During the years of motorization study, some rather radical changes in the design of farm motor equipment have been made. Whether or not we have the last word in design and construction remains to be seen, but with the demand for better and more efficient tools it may be expected that some novel and rather startling designs will be forthcoming in the future, for our designers and engineers are ever alert.

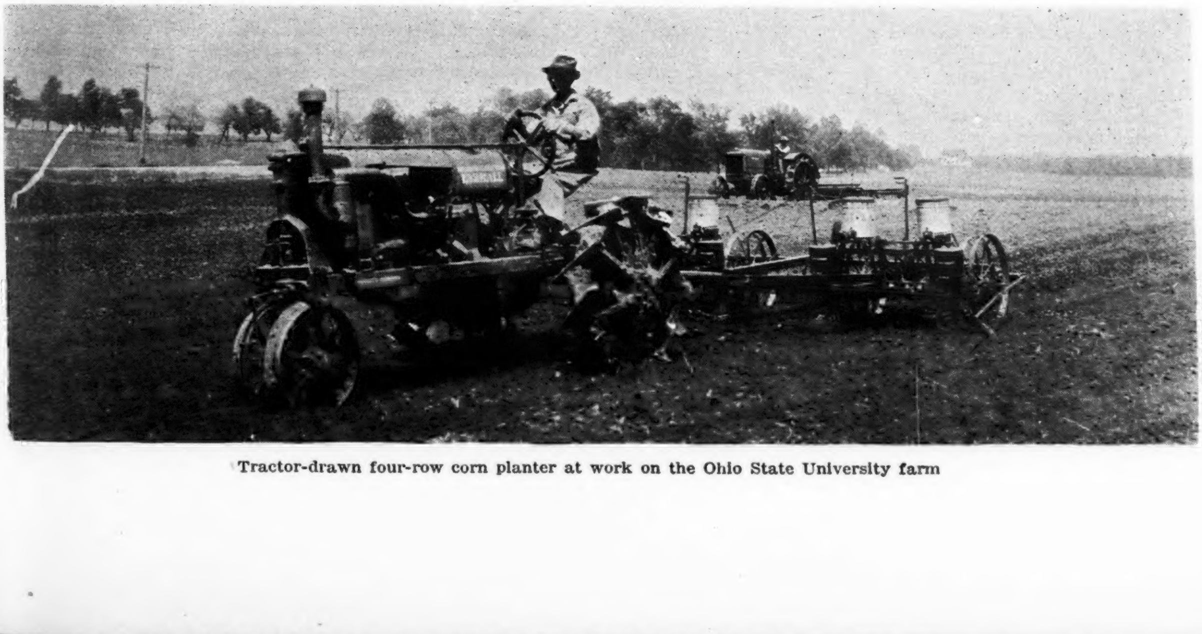
There is not much to add to what has been previously presented on the subject of the motorization of the corn crop[2]. However, there are some sidelights obtained during the study that may be of interest and have a direct bearing on the productive work of the operator, that is, the chores on farm equipment.

It has been often said by users of the older types of tractors and equipment that it nettles them to see their neighbor

*Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December, 1926.

[1]Professor of agricultural engineering, Ohio State University. Mem. A.S.A.E.

[2]"Motorizing the Corn Crop in Ohio," G. W. McCuen. AGRICULTURAL ENGINEERING, December, 1924. (Vol. 5, No. 12, pages 268-270. Also A.S.A.E. Transactions, Vol. 18 (1924), pages 78-83.



Tractor-drawn four-row corn planter at work on the Ohio State University farm

making a couple of rounds with their horse equipment while they were getting their motor equipment ready for the day. Th's is more a state of mind rather than a reality, for no doubt if the actual time to get both types of power ready for work and taking care of them at noon and night were recorded, the power farmer would find he had put a lot more time in actual field work than his neighbor using animal power.

If we are to consider the chores of a tractor and charge it against the day's work, it would then only be fair to charge the animal chores against the day's work.

The chores of a tractor are quite in proportion to the design and system of greasing used. With the use of positive high-pressure greasing equipment, the time consumed to get the machinery ready for work is cut down materially. Last season the disk harrow and soil packer we used were equipped with a contact system of lubrication, and with the use of a gun loader it was found that the chore time was reduced 6.6 per cent. Labor being one of the items of the cost of production, it is highly important to devote as little of the operator's time to this necessary, yet unproductive work. The average chore time for different tractors and implements as generally equipped by the manufacturer was found to be 9.5 per cent of the total time in the field, and when equipped with a contact system and using gun loading equipment only 3.9 per cent of the total time was required for chores. The small extra investment in this equipment will be offset by the operator devoting his time to productive work.

Another interesting fact that has come from our motorization study has been the time saved at corners when plowing. Some tractors do not have a quick and short-turning steering apparatus while others have this essential feature. Ohio does not generally plow her farm fields in several lands as is the practice in western states; it is plowed in one large land, throwing the land either in or out according to the way the field was previously plowed. With this method of plowing a unit with a quick-steering apparatus and a short-turning radius has a distinct advantage. The average of time lost at the four corners of the field has been found for all units to be 4.75 per cent of the total running time. The variations were 7.05 per cent of total running time as a maximum to 2.39 per cent as a minimum. It is believed that the average of 4.75 per cent time lost will be what the majority of plow operators will lose when plowing fields in this manner. These two items, chores and idling, are small but must be watched so as to make the operators time most productive.

This year we were privileged to try out some new equipment in the work of corn production. A four-row planter and four-row cultivator were used for the first time. Whatever data are quoted must not be considered as final for the operators were not intimately acquainted with the equipment. The data, however, will show what the trend of design will do toward lessening production costs.

The four-row planter as we used it was very satisfactory. The field was level river bottom land which made it possible to use such a unit and obtain excellent results.

Table I shows the comparative data of the two-row and four-row motor planters. The acres per hour for the four-row planter would have been greater had it not been for the fact that 125 pounds of fertilizer per acre were dropped in the hills. The rows were 140 rods in length which necessitated the carrying of a full sack of fertilizer to the opposite end, each round, for refilling. No fertilizer had been used in previous years so the data are not entirely comparable. However, they indicate that there can be a considerable saving

This unit has possibilities where the fields are level and large enough to warrant its use. A good check was obtained in the center of the field, but at the ends there were evidences of wire travel. However, it was not bad enough so that the ends could not be crossed with the four-row cultivator.

TABLE I. Comparative Data of Two-Row and Four-Row Motor Planters

Equipment	Acres per hour	Man-hours per acre	Fuel, oil, grease per acre	Labor costs per acre	Total operating costs
Two-row planter	1.50	0.666	\$0.229	\$0.266	\$0.495
Four-row planter	3.26	0.612	0.112	0.224	0.354

Dragging or harrowing corn after planting has been and still is in many instances the bugbear of farm operations. It is a job to be loathed by all, but when the first cultivation is made as the corn is just peeking through the ground, with a motor cultivator pulling a twenty-foot section of spike tooth harrow, it becomes a pleasure for the quick accomplishment of work well done brings a great deal of satisfaction to the operator. It has been found that an average of 6.54 acres can be covered per hour with a fuel-oil-grease cost of 60.5 cents and a total labor charge of 6.1 cents making an operating charge of only 11.1 cents per acre.

In some places the rotary hoe is used very successfully for the first two cultivations. Last summer it was my privilege to see the 80-acre field of corn on the Illinois agricultural experiment station farm, that had been completely motorized under Prof. R. I. Shawl's direction, using rotary hoes the first time through covering 8.4 acres per hour and later cultivated at the rate of 4.84 acres per hour. This field laid next to other fields of corn which had been handled in the usual way. The motorized field was clean and the other fields were weedy and grassy. Further comparisons are not necessary.

To cultivate four rows of corn requires the undivided attention of the operator to do a satisfactory job of cultivation. We were unable to do the acreage per hour that might be expected of such a sized rig, because the field being river bottom land which was flooded early in the spring was very foul with all kinds of weeds especially morning glory. At the end of each round and in some instances oftener it was necessary to stop and "unwreath" the cultivator gangs. There being sixteen of the gangs, quite a little time was lost in this sort of work. In spite of the handicaps of morning glory and an uneven check at the end of the field, a creditable piece of farm work was done. Table II shows some interesting comparisons between two and four-row cultivations. Again it is to be remembered that the four-row cultivation only covers one year while the other is for a period of four years.

While the man-hours of labor saved per acre do not show so much in favor of the four-row rig, due to conditions previously mentioned, there is a noticeable saving in the fuel requirements of the motor. This would lead one to believe that the four-row rig was more nearly the ideal working load for the tractor than was the two-row rig.

The four-row cultivator may not be what we would desire ultimately, but in its present state it worked quite satisfactorily, and we believe with some minor changes it will be as practical as the present two-row machine.

To completely motorize a corn crop a corn picker must be used.

There is but little value in the stover left in the field for winter pasture. The question of the value of corn stover as a winter feed is debatable in the minds of many farmers. This is especially true in Ohio where a large area of corn is cut for the stover. Dr. Falconer and Prof. Dowler together have gotten some very interesting data on the value of corn stover. In Ohio Agricultural Experiment Station Bulletin 396 they make this statement:

"The stover is a minor item of consideration yet it influenced the profit or loss on the corn crop as a whole, and its value should have some influence on the method of harvesting employed. Assuming that the corn was cut to secure fodder, the following computation would give some idea of the cost of the stover, based on the assumption that all expenses of cutting and husking corn over and above that of husking from the stalk should be charged against the stover. If the corn had been cut and husked by hand, half by regular labor and half by contract labor paid by the shock, the costs would be \$3.65 per acre for cutting, \$6.32 for husking and cribbing, and \$3.58 the actual cost on the farms of haul-

TABLE II. Comparison of Two and Four-Row Cultivations

Equipment	Cultivation	Acres per hour	Man-hours per acre	Fuel, oil, grease per acre	Labor costs per acre	Total operating costs
Two-row cultivator	1	1.65	0.605	\$0.180	\$.244	\$.428
	2	1.87	0.534	0.151	.214	.365
	3	2.37	0.418	0.118	.167	.285
Four-row cultivator	1	2.82	0.354	0.088	.141	.229
	2	2.42	0.413	0.083	.165	.248
	3	3.17	0.315	0.062	.126	.188

ing an acre of stover to the barn or feed lot. This would have made a total cost of $13.55 per acre. The cost of husking and cribbing an acre of corn from the stalk was $5.35 per acre without giving any credit for stalk pasture. This would have given a difference of $8.20 ($13.55—$5.35) in the cost of harvesting by the different methods. The average yield of stover was a ton to the acre. The cost of stover at the barn as feed was, therefore, $8.20 per ton. Compare this for feeding purposes with the value of hay in the barn, which averaged $12.50 per ton during the period of the study. According to Henry and Morrison's 'Feeds and Feeding,' corn stover is worth only one-third as much as mixed clover and timothy hay when fed to cows. On the basis of this comparison, therefore, a farmer would not be justified in spending the extra cost of cutting and husking from the shock merely to get the stover to feed, unless hay were unusually high in price."

These facts have set the advocates of feeding corn stover to thinking and give the users of modern corn harvesting machinery a firmer belief in the practice they are following. The saving by using machinery is not swallowed up by the loss of winter feed.

In the future, farm machinery will make it possible for the farmer to practice greater diversification. This, together with the reduction of production costs, will bring about a more stable agriculture. Today the agricultural worker is not producing as much as the factory laborer because of lack of equipment. Why is it the average farm lad can go to the city garage and earn more than he can on the farm? The answer is this: Adequate equipment multiplies his effort to such a degree that the products of his work is profitable at the higher wage he is paid. To substantiate this further I will quote from the October 15, 1926, issue of "Farm Machinery and Hardware:" "From 1840-1925 the percentage of farm workers has decreased 53 per cent; acreage per worker has increased 48 per cent, and the dollar production per worker has increased 419 per cent compared with the factory worker's increase of 373 per cent."

The farmer has not reached a production value per worker compared with the industrial laborer, yet he is nearing it. The decade of 1910-20 brought an increase in value of production per farm worker of 2.3, while the industrial worker's increase was only 2.2. The increase was due to more and better equipment on the farm. The future will see a still greater increase when machinery is given proper consideration.

Today we are finding in Ohio that the purchase of machinery is being given the kind of consideration that it should be given. The sales record of one of the branches of a company manufacturing a general-purpose tractor reveals the fact that in 1924 four units were sold; in 1925 eight were sold, and this year, 1926, there have been 140 units sold.

Taking this idea of machinery consideration still further, just recently twenty farmers in Ohio were selected, publicly recognized as "master farmers," and given gold medals as a token of their achievements. The fact that 100 per cent of these master farmers are power farmers is significant of the fact that these men, who have large labor incomes, who are outstanding citizens, and who are good business men in addition to being good farmers, recognize the value of mechanical power on the farm. In the closing speech at the master farmer banquet our venerable director emeritus of the Ohio Agricultural Experiment Station, Dr. Chas. E. Thorne, struck a keynote when he said, "Machinery has done a lot for agriculture; it has done a lot to relieve man from heavy burdens; and will do a lot for him in the future; but too much cannot be expected from it unless the farmer mixes brains with it."

If, speaking for Ohio conditions only, it is possible to reduce the time necessary to grow and harvest a crop of corn from 26 to 5.77 man-hours, and since labor is 54 per cent of the total cost, then motorization of the corn crop is practical and economical as it makes it possible to use labor to the greatest possible degree of efficiency.

Mechanical Equipment in Corn Cultivation*

By R. I. Shawl[1]

IN FARMING, as in any manufacturing enterprise, there are two big items of expense to be considered in the cost of production, namely, the fixed expense and the operating expense. The fixed expense cannot be greatly reduced, but the operating cost of production can be controlled to a large degree by the producer. Since the farmer cannot control the price he receives for his crops, his only salvation is to cut down the cost of production. Man gets paid for what he produces with little consideration to the effort put forth in producing it. When we consider that man and horse labor together make up 60 to 80 per cent of the total operating expense in producing corn and other crops, it would seem that here is the logical place to start cutting the cost of production. The salvation of the farmer is in the production of more bushels per man, and those farmers who are equipping themselves with modern labor-saving machinery, under good management, are rapidly forging ahead.

The question of the use of mechanical equipment in corn production is a very important one in Illinois, when we consider that Illinois with its 316,317,000 bu. of corn, ranks second among the corn-producing states. Therefore, with a view to finding ways and means of reducing corn-production costs, the department of farm mechanics of the University of Illinois has been making a study of the use of mechanical equipment for corn production. For this purpose an 80-acre field was secured upon which a general-purpose farm tractor, designed to plow and prepare the seedbed and cultivate row crops, was used.

This field was comparatively level and the soil was a brown silt loam with some clay spots on the higher places. The actual operation and maintenance of the tractor was taken care of by one of the men regularly employed on the University of Illinois farm, under the author's supervision. The term "total man-hours" as used in the table and in the discussions that follow is the time the man actually spent in the field. Total tractor-hours are the hours the tractor motor ran in the field. Tractor chores include greasing; changing oil; filling with water, fuel and oil, and cleaning spark plugs. Labor on the tractor at the shed, making minor repairs and adjustments, is included in the labor charge for overhauling the tractor.

The tractor with two-row cultivator attached was secured in June, 1924, and was immediately put to work. That spring was a very wet one in Illinois, and it was forty days from the time the corn was planted until the cultivator was started. The corn was from 3 to 5 in. high by this time and the grass and milkweeds had made considerable growth in some parts of the field. We had difficulty in killing the milkweeds until 10-in. sweeps were substituted for the 6-in. ones with which the cultivator was equipped. The corn was planted the short way of the 80-acre field and it required 48 hr. to cultivate the field the first time or 0.6 tractor-hours per acre. The second cultivation required 44 tractor-hours and the third cultivation was completed in 39 hr., or 9 hr. less than the first time.

In 1925 and 1926 the entire work of putting in the corn on the 80-acres, from disking the stalks through the third cultivation, was done by the tractor. The implements used during these two years were the same except that a four-row planter and four-row cultivator were used in 1926 instead of the two-row planter and cultivator used in 1925; and for one harrowing and rolling two 7-ft. soil packers and three spike-tooth sections of harrow were used in 1926 instead of one 7-ft. soil packer and two sections of harrow used in 1925. The following nine operations were performed: Disking stalks (tandem disk), plowing (28-in. gang), disking plowed ground

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(tandem disk), harrowing and rolling, planting, harrowing and rolling, and three cultivations.

In 1925 a two-row check corn planter was used and the corn was planted the short way of the field. Two men were used, the additional man operating the planter. It required 44 tractor-hours and 88 man-hours to plant the field. This was at the rate of 1.80 acres per hour, or 0.55 tractor-hours per acre.

In 1926 the field was planted the long way. A four-row check planter was used with two men and it required 19.5 tractor-hours and 41 man-hours in the field to plant the corn. This is less than half the time required in 1925, with a rate of 4.10 acres per hour, or 0.244 tractor-hours per acre. The planter worked successfully; however, the check was not very straight.

In 1925 the corn was quite small when first cultivated. It required 53 tractor-hours, using the two-row cultivator the short way of the field, for the first cultivation of the 80-acre field, a rate of 1.5 acres per hour. Fifty-four hours were required on the second cultivation. This slight increase of time probably resulted from the lack of a good check. The third cultivation was accomplished in 34.5 hr. or 18.5 hr. less time than the first. The tractor was operated at a greater speed the third cultivation without danger of covering the corn.

In 1926, using the four-row cultivator the long way of the field, it required 21.5 tractor-hours for the first cultivation, a rate of 3.72 acres per hour. This was a faster rate of cultivation than was attained at any time with the two-row outfit. Because of a poor check and cultivating the short way, 4.5 hr. more were required for the second cultivation. The third cultivation was accomplished in 16.5 tractor-hours, a rate of 4.85 acres per hour.

It should be noted that the tractor-hours, man-hours, and fuel used per acre were all greatly reduced by the use of the four-row cultivator over that of the two-row cultivator. The four-row cultivator is more nearly the proper load for the tractor than the two-row.

The four-row cultivator did a fine piece of work and left the field quite free from weeds. Prof. G. W. McCuen, of Ohio State University, in looking over the field, remarked that it was exceptionally clean. The operator of a multiple-row cultivator can watch but one row at a time and many farmers, especially those using one-row machines, are afraid of covering up the corn or plowing out too much of it. I am of the opinion that the money value of the man labor, tractor labor, and fuel saved by the use of the four-row cultivator amounts to many times the value of the corn destroyed by this machine.

In 1925 it required 416.5 tractor-hours, or 5.2 tractor-hours per acre, and 470.75 man-hours, or 5.87 hr. per acre, to put in and cultivate the 80-acres of corn. In 1926 it required 294.06 tractor-hours, or 3.67 tractor-hours per acre, and 342 man-hours, or 4.28 man-hours per acre to do the same work. In 1926 records show a saving of 1.53 tractor-hours, 1.59 man-hours, and 1.35 gallons of fuel per acre over that of 1925. With tractor costs of 81.2 cents an hour, man labor at 50 cents an hour, kerosene at 14 cents per gallon, and gasoline 18 cents per gallon, there was a saving of $2.23 per acre for the three items mentioned over the cost in 1925. This saving is due largely to the use of four-row equipment.

No attempt has been made here to determine the total cost of producing an acre of corn, but the figures for the cost of operation of the tractor per hour are listed in the table following.

During the 2½-year period the tractor was operated 860 hr. On the basis of 3,000 hr. work, or at the rate of 400 hr. a year for 7½ years the depreciation per hour on the tractor valued at $920 is 30.7 cents. The interest on the investment is figured on the average investment or straight-line depreciation. From the list of items noted in the table, the cost of operation of the tractor for the 2½-year period is 81.2 cents per hour.

From the data presented this type of tractor has shown its ability to do the heavy field work and to reduce the peak load of man and horse labor by its ability to cultivate row crops. Any tractor that will not only do the work of horses in cultivating row crops but which can do it in so much less time is certainly of great interest and importance to the corn grower and other row crop farmers.

SUMMARY OF TRACTOR COSTS FOR 1924, 1925 AND 1926 IN FIELD OPERATIONS CARRIED ON BY THE DEPARTMENT OF FARM MECHANICS, UNIVERSITY OF ILLINOIS

Depreciation[2], 860 hr. of tractor work at 30.7 cents	$264.02
Interest on investment[3], 6% of [(920 + 122.80) ÷ 2] x 2½ years	78.20
Fuel used—	
54.9 gal. gasoline at 18 cents	9.88
1,123.75 gal. kerosene at 14 cents	157.32
Crankcase oil, 70.66 gal. at 80 cents	56.52
Grease, 30 lb. at 15 cents	4.50
Transmission oil, 4 gal. at 60 cents	2.40
Repairs[4]	36.12
Labor overhauling tractor, 51.5 hr. at 50 cents	25.75
Expert labor overhauling tractor, 5 hr. at $1.25	6.25
Tractor chores[5], 116 hr. at 50 cents	58.00
Total cost of tractor operation	$698.96
Cost of operation of tractor per hour	$ .812

[2]The life of the tractor is estimated at 3,000 running hours, or approximately 7½ years.

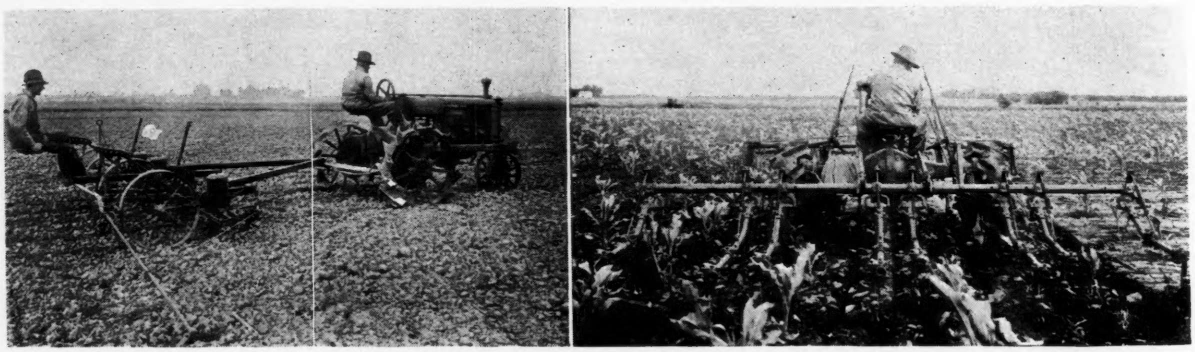
[3]Cost of tractor, $920, including freight.

[4]Repairs include spark plugs, wrist pins and bushings, small gear, piston rings, fan belts, magneto breaker points, shaft bushing and brake band linings.

[5]Tractor chores consist of greasing, changing oil, filling with water, fuel and oil, and cleaning spark plugs.

Utilization of Energy

MODERN civilization is sharply differentiated from civilizations that have preceded it by the incomparably greater extent to which it utilizes energy. For this energy it depends chiefly upon the various forms of fuel. Two pounds of coal will develop as much energy as a man at heavy labor for a day. The industrial status of a country is, therefore, largely determined by the supply of energy available to the individual worker. Nowhere is this supply comparable to that afforded in the United States. While the white population of the world increased about three times from 1815 to 1914, the production of mineral fuels—coal, oil and natural gas—increased seventy-five times; and by far the largest proportion of this increase has been in our own country—Arthur D. Little



In the 1926 studies at the University of Illinois, of the use of mechanical equipment in corn production, a four-row planter and a four-row cultivator were used. This equipment resulted in a substantial decrease in production costs over the year previous when two-row equipment was used

Research in Agricultural Engineering

A department conducted by the Research Committee of the American Society of Agricultural Engineers

Research in the Making as Applied to Agricultural Engineering*

By E. W. Allen[1]

THE past few years have marked notable development and improvement in the character of agricultural research, in which that relating to agricultural engineering has not been left behind. Indeed the attention given to outlining its field and relationship to other research, defining and analyzing the problems it includes, and devising means for studying their essential parts, is one of the noteworthy features of this recent growth.

In this period of placing agricultural engineering on a more sound research basis, generalities and intangibles have been gradually giving way to the more definite and concrete questions of what should be done, how to do it, and where to recruit the forces for research. These matters have occupied much attention with results which are more and more gratifying.

It will be admitted that there have been many false starts and considerable lost time and delays. On the whole, however, these have not been more than was to be expected when one considers the almost complete absence of background in the subject in the beginning, the lack of trained research workers, and the natural inertia of administrators of research toward the adoption of an apparently new and untried idea as a research possibility.

And the work has little more than begun. In fact, the evidence shows that the growth in amount of the work has been relatively small during the past decade. The change has been rather in the quality of the research, and this after all is as it should be. The experience so far has therefore been largely preliminary experience to determine more definitely what it is all about and what to do about it. The main thing now is to take full advantage of this preliminary experience, and as rapidly as possible prepare to further meet the requirements of sound investigation and of growth. This will mean the promulgation and acceptance of proper conceptions of research and what it implies.

In its early stages research in any subject tends to be of rather elementary character, and the essentials which characterize it and its aims as a scientific activity may be somewhat obscure to the inexperienced. This seems to have been particularly true in agricultural engineering, since research efforts in the subject have evidently in many cases been confused, for example, with the layman's viewpoint and the end he seeks. The terms "experiment" and "investigate" have in many instances been in popular use as applied to agricultural engineering subjects, referring to attempts to advance individual or collective information by quite superficial means. The rank and file speak of "making an experiment," meaning to try out different things or ways to see if one is better suited to the purpose than another—not to get at the reason or to add an exact general fact but for personal information or advantage. Man's experience is composed of such personal trials and experiments, made without definite control and resulting largely in personal opinion. Service trials of farm implements and machinery perhaps most strikingly exemplify this sort of experience so far as agricultural engineering is concerned, and the results of such work have with time become more or less recognized empirical facts.

Similiarly, the layman "investigates" various subjects, meaning that he looks into them personally, becomes familiar with them, and receives what he considers a basis for judgment. He "investigates" a new route or a tract of country with which he is not familiar, or the extent to which a practice in his region is profitable, or attempts to verify by personal observation something that has been told him. He may investigate by reading, or he may attempt to get a personal opinion by an examination or a rough enumeration.

This popular view of experimenting and investigating seems sometimes to influence the manner of thinking about a research project in a practical field. It is reflected in the subjects and methods of project outlines—the purpose to deal with large many-sided questions rather casually, as if they could be solved as a whole, with more emphasis on superficial impressions than on sound conclusions. This is not peculiar to the subject of agricultural engineering, but it fails to comprehend what research implies.

Research is another name for investigation, and in most lines it employs observation, trial, and experiment; but these differ from the every-day variety by being so framed, directed, and controlled as to disclose if possible a scientific fact, one expressing an exact situation and taking into account the limiting or modifying conditions surrounding it. The means employed is known as the method of science, characterized by an orderly, thorough, and exact procedure. In this sense investigation, experiment, and the gathering of observations deal with things that have some degree of permanence, are definitely characterized and measurable, such as natural phenomena or a condition that has become static. Account is taken, not only of the individual observations and facts, but of their relationships to one another or to their surroundings, in order to understand them and what they signify, and if possible to throw light on the causes and the reasons for them. The conclusions from such inquiry may be assumed to be more reliable and far-reaching than common experience, which has no standing in science until tested and verified.

So it will be evident that the approach, the motive, and the method in research are quite different from those employed in every-day life, and this fact affects the manner of thinking about a subject for research. The more practical the question, the more carefully it may need to be studied to determine what it embodies and by what avenues and divisions it may be approached. The motive is significant because it expresses the strivings and the goal of the worker and conditions his efforts. In a given case it may differ widely: In a plow or tractor-wheel study, for example, the actuating motive may be to make an addition to or strengthen some point in the theory of soil dynamics, to ascertain comparatively some practical improvement for the time, place, or conditions, to accumulate routine data without any particular design but in the hope that they may be useful, or to accomplish some other purpose.

Routine operations are not to be confused with research, no matter how technical they may be. The following through of a professional technique is not necessarily a searching

*EDITOR'S NOTE: An adaptation of an article, entitled "Research in the Making," published in the Journal of Home Economics, Vol. 19, 1927, No. 7, pp. 367-373. The principles of research and related factors were so clearly and instructively laid down in the original article that the author was induced to again present the subject, adapting it more specifically to research in agricultural engineering. This he has done, making use of his broad knowledge of the development of the work in agricultural engineering during the past decade at the agricultural experiment stations. The kindly, constructive criticism of the efforts of agricultural engineers and the sympathetic interest in and understanding of their difficulties by the author makes this article one worthy of reading and rereading.

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process. The making of chemical analyses or physical determinations are routine operations after the methods have been worked out, although the use to be made of the analyses and determinations, the selection of those necessary, and the adaptation of the processes to the object in view may make the operations not only a means but an essential part in investigation. Carrying out the field work of a survey may be purely routine, as much as the taking of a census—and sometimes has been; but the intelligent inquiry injected by the investigator and the things he discerns apart from the mechanical formula of his questionnaire rob it of its routine and, with the use made of the data, may raise the work to research grade.

Similarly there is a distinction to be observed between research and a service. The agricultural engineer, for example, surveys a piece of land for a drainage project, determining accurately its boundaries, topography, and area, and in so doing adds a new fact, one scientifically verifiable. But he has done no research; he has performed a technical operation, applying something which science has taught and thus rendering a service it has made possible. A survey of the tillage practices of a region, on the other hand, if designed to be a piece of research, will aim not merely to get data on the kinds of plows used and the depth of tillage, but to form an accurate idea of the adequacy of the tillage in depth and degree of pulverization, its relationship to the germination, growth, and maturity of specific crops, the possible means of improving or cheapening it, and to learn everything possible about the subject that will not merely help the farmers concerned but will also add to the general knowledge of tillage. And so it must include the study of conditions other than the machines which have a bearing on the subject, determine the amount of such data necessary to validity, and try to get an accurate, reasoned generalization.

There is this difference, then, between service and investigation, that one is routine dependent on individual skill or knowledge or both, while the other is a searching for new knowledge in order to make it usable.

Research proceeds by means of securing facts. These are the bases of evidence, and the evidence is the foundation of conclusions and generalizations. But facts differ greatly in their research value, and they need to be determined scientifically even though they may relate to the practice of a people or their traditions. The interest in individual facts lies rarely in themselves, but in how they may be combined into a general fact or truth. Furthermore, facts differ widely in their value in advancing a piece of research. Even among well-established ones some have no reach and teach nothing beyond themselves, while others mark a definite step in advance and suggest things which they do not reveal. Such facts as the latter not only give insight but foresight.

This visualizing of the kind of facts needed for advancing an investigation and the selection of those applicable gives direction to the accumulation of facts by going after those specifically needed. This naturally requires alertness and ingenuity, and it will guard against routine or continued accumulation beyond the point necessary. The use of conventional methods is no excuse for the research to become conventionalized.

The fact that research is not static but a process of development suggests another consideration. In almost any subject in which investigation is active, the status of inquiry is in a constant state of change, as the result of advances and the effort to make further progress. So if one would make a contribution the actual status of a subject should be studied first, and the project then framed so as to add a new point or suggest a new idea. It is in this way that progress is made—not by the indiscriminate and continuous accumulation of data or repetition without considering the need and the reason for it, but as far as possible by suiting the means to the desired ends.

There is a tendency sometimes for reseach to become stereotyped, to follow well-beaten paths, repeating in a different locality what has been done many times elsewhere. The repetition of tile drainage tests, of simple duty of water experiments, or of tests of well-known types of farm machinery in different localities, without adequate consideration for the requirements of the different conditions to be met, results ultimately in such stereotyped procedure. The continued accumulation of evidence without a definite reason or purpose lacks originality and becomes little more than a demonstration. The opportunity for advancing the subject is lost, as if there were nothing more to be done.

There is small danger of exhausting a subject if the research is forward-looking; it is what the investigator is able to put into it that makes it forward-moving. This implies ability to grow with his problem, which is a very important essential.

This view of research and its qualities naturally leads up to the dominant element in it, the individual. Already he is seen as the first and foremost essential. Upon him will depend the initiation and the prosecution of investigation that is sound and constructive, guided by clear conceptions and motives.

To the person with taste for it, research is the most fascinating pursuit imaginable. But it is one of the most exacting pursuits, and it makes large demands on individual qualifications comprised in natural aptitude, training, and standards. The enlarged opportunity and the appeal which even a superficial understanding of it may make probably have attracted some to the new field who, without realizing it, were not fully equipped for it. These have had to learn in part both the spirit and the substance of research after they entered the work, and thus have been under considerable handicap at the start. The extent to which this handicap is overcome and resourcefulness developed only time and individual attitude will tell.

Enthusiasm has been much in evidence but not always a helpful guide. It may spring from desire without appreciation of what is involved, and hence of personal limitations. It can not, of course, take the place of the ripened judgment which comes through training and intimate contact with research. The need for a frank realization of individual limitations, and of the fact that apprenticeship may be a desirable prerequisite to the assumption of leadership, is one of the lessons that stand out clearly.

Overconfidence and deficient preparation are likely to lead not only to loss of time but to efforts which are disappointing or even abortive. In such cases subjects are not thought through as to ways and means, or the technique mastered as a preliminary. This sometimes has been illustrated, for example, in new machinery research. Despite the extensive literature on this subject and its advanced status with reference to other industries, the field has been entered into by some agricultural engineers with little preparation and with surprisingly little detailed knowledge of the technique, the properties of the structural materials, the kinematics of the assembled machine, the analytical mechanics of the operation to be performed, and similar elementary matters. These have had to find their way at the expense of their station work, with much loss of time and often with results which need careful checking. One danger is that unless the general grade of the farm machinery research is maintained on a parity with that in other industries it may fall into disrepute. The efforts of certain national agencies to prevent this very thing and to place the farm machinery research on a more sound basis is indeed gratifying.

The opportunity for a career in research ought to be a spur to take it seriously and to prepare for a growing part in it. This usually will mean special study.

One of the most fundamental and permanent products of advanced study is the development and quickening of the spirit of research. The knowledge added to the individual equipment by advanced systematic study is an asset not to be underestimated, but the opportunity to come under the tutelage of a master mind, to understand how questions are framed and broad facts developed, and to imbibe something of the spirit which lies back of research, transcends all else in importance, for it represents a new growth and a new means of further self-advancement.

Similarly the quickening of the spirit of research is one of the primary advantages of association with other workers and of attendance at scientific meetings. Such contacts, if of the right kind, are a spur which keep the investigator stimulated, and make him exacting of himself.

Research tends toward specialization. It leads the investi-

gator from the general to the specific. In a subject so comprehensive as agricultural engineering, one can not expect to know intimately the whole field, the latest contributions and methods, and the advanced theories. If he is to press steadily forward, he must concentrate sooner or later on some particular branch, so that his knowledge and judgment will be that of an expert and his speculation not too widely scattered. The teacher may have to cover a broad field, and hence must keep posted in a general way over the whole range of it; but research follows narrow paths, especially after it gets well under way, and is increasingly intensive and specialized as it advances. These things point toward selective discrimination in advanced study and in reading—not too narrowly but in accordance with the position of the worker and the character of his research.

In a word, therefore, research is what the individual makes it, his motives and what he is able to put into it. Its character reflects his strivings and the goal he has set; and largely these determine whether the result will be a statement of a case, an analysis of a situation, a simple comparison, or the evolution of a general fact.

Standards, outlook, motives, and procedure are prime factors in defining research, and they follow and qualify one another like the links in a chain. The standards reflect the attitude toward research, the spirit and qualities developed out of training, experience, and natural aptitude. The outlook gives the vision of problems and their analysis so that they can be attacked as effective working parts. Upon the standard and outlook largely will depend the underlying motive—the aim, the penetration, and the reach of a piece of work, whether it be a survey or a laboratory investigation. And these together will underlie the procedure, determining the methods selected or devised, the extent to which the mechanics of them are supplemented and the design exercised in searching out key facts.

All of these qualities will be recognized as more or less personal and individualistic. Each is aroused, stimulated, and strengthened by training that is broad and intensive and develops independence; but the individuality remains a large and often latent factor. Upon it depends how hard one will think and how much imagination and initiative one will inject into the routine of investigation. These qualities rarely can be predicted, and hence demonstrated zeal and ability carry large weight in the selection of workers, especially for independent positions.

Passion for excellence is at the base of the best work in science, as it is in art and literature. The investigator needs to cultivate this passion, to feel something of the divine fire burning within him; if he does he will seek to keep it burning and let it be reflected in the motives and the plan of his research. He must lay within himself the foundations for continued growth, and then maintain the contacts which will stimulate and quicken it.

Research in Agricultural Engineering, 1926*

By R. W. Trullinger[1]

(Continued from the September issue)

MATERIALS OF CONSTRUCTION

Considerable work was continued for the purpose of more definitely establishing the specifications for materials used in farm equipment and structures, based upon the requirements for their use.

Concrete. In a continuation of cooperative studies with the U. S. Department of Agriculture, the Minnesota station established the necessity for a hardening period for all high-alumina cement-concrete exposed to the action of sulfate waters. All the tests indicated that high-alumina cement is somewhat more resistant to the action of sulfate waters than is most standard portland cement. However, it is not 100 per cent resistant. It was found not feasible to mix alumina cement with standard portland cement except within very narrow limits. It was also found that concrete, regardless of how well cured in water, must subsequently be allowed to dry thoroughly and harden before being exposed to the action of sulfate waters if great resistance to attack it to be expected.

In continuing studies of the deterioration of concrete in alkali soils, the University of Saskatchewan made a comparison between the contraction and expansion of portland cement mortar bars when alternately dried and wetted in water and in sulfate solutions. It was found that the expansion method for studying sulfate action on concrete has very marked advantages when the action progresses very slowly and the experiments last for months or years. Although the time of curing is an important factor affecting expansion of mortar bars in sulfate solutions, comparisons of bars cured the same length of time, whether for one week or more, give similar results, and after one month the effect of time of curing is very slight. Comparisons of the expansion of mortar bars in sulfate solutions were found to be not permissible when the ratio of amount of mortar to amount of solution varies. The effect of richness of mixture on expansion of mortar bars was somewhat greater in the case of solutions of magnesium sulfate than of sodium sulfate. For solutions of both salts the effect of concentration above molar on expansion was almost negligible, and between molar and 0.5 molar very slight. For solutions of lower concentration the effect is more marked, and below 0.05 molar the slowing down of the rate of expansion is especially marked in solutions of sodium sulfate. The expansions in saturated solutions of the two salts were nearly identical. The same applies to 0.1 molar solutions. Below this concentration there is a marked difference.

The engineering experiment station of the State University of Washington conducted studies of combined concrete and timber in flexure which may be of considerable significance in the development of economical farm structures. It was found that timber may be made to take the tension and concrete the compression in a structural member. It was also found that concrete and timber combined as a single member will produce a beam several times stronger than the same quantity of materials not so combined. Increased stiffness is secured, thus reducing deflections and vibration. Adding the concrete to the timber produced a beam nine times more rigid than the original timber. Rough timber may be used resulting in greater strength and a reduced cost by avoiding the surfacing operation. Irregular dimensions in the unsurfaced material are not objectionable, since this is compensated for by the plasticity of the fresh concrete. The form cost is reduced, since the timber carries the dead load while the concrete is setting.

Adobe Brick. The Colorado station found that soil containing a large amount of clay is essential for making good adobe brick. The binding material must be added in the form of cut straw or chaff, the soil should be puddled thoroughly, and enough water should be added to make a mud easily handled with a six-tined fork and yet stiff enough to retain its shape when the forms are removed. The brick should be protected from moisture and frost while curing.

Rammed Earth. Moisture content and the rate of putting the earth into the molds were found by the California station to be factors influencing the strength of rammed-earth structures. No great difference was observed between the strengths of fine sandy loam and clay loam material. Fine-grained sedimentary soil with a high colloid content was found to act differently from other soils when under stress. The rate of drying was found to be an important factor in the ultimate strength of rammed earth as well as in the effect of the straw. An elastic limit of this material was observed in compression tests which was most marked in Yolo fine sandy loam.

Fence Posts. Work on the preservation of fence posts has continued. The Arkansas station found that lime-sulfur

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spray solution has little value as a wood preservative. Ten per cent of posts so treated were unfit for further service and the sapwood was decayed to a depth of ¾ in. Steel posts showed considerable rust on painted specimens after four years' service, while galvanized posts were in good condition. Of 148 butt-treated, open-tank-process, creosoted green oak posts, 22 per cent were unfit for service after five years. Tests to determine a practical method of treatment of wood with water-soluble toxic salts showed that on the average slightly more salt was absorbed by cooking the specimens for 2 hr. at 180 deg. F. than by soaking over night in a cold solution. Most of the absorption occurred in the first hour of heating. Steeping in a cold solution for as long as 24 hr. per in. of thickness did not cause sufficient penetration, only about half as much dry salt being retained as in the heating process.

Timber Failure. Studies by the U. S. Forest Service on the relation of the manner of failure to the structure of wood under compression parallel to the grain showed that slip lines, or slip planes, are the first indication of injury in compression parallel to the grain, but it is doubtful whether they are likewise produced in tension along the grain. The initial failures, consisting principally of numerous localized slip planes, showed no such distinctive difference between their radial and tangential aspects as that exhibited by gross failures. Apparently, however, they are sources of zones of weakness within which the buckling of the fibers resulting in gross failures may start more easily than elsewhere. The gross failure in compression parallel to the grain consists of a buckling of the fibers. The least amount of friction between fibers occurs when the plane of buckling or failure is inclined. The inclination of the failure occurs as a rule in a tangential direction. The only probable explanation of this behavior is that the medullary rays increase the resistance to buckling in a radial direction, thus causing the line of failure to be inclined on the tangential surface. It seems likely that investigations such as this will gradually place the design of timber farm structures on a more substantial basis.

Strength of Metals. At this time, when the further development of much of the farm machinery seems indicated, it may be of interest to note some of the efforts being made to develop metals for such use. For example, the engineering experiment station at the University of Illinois has conducted studies of the strength of cast steel as a material and of the effective strength of this material in different parts of a casting as modified by internal strains, minute cracks, and foreign inclusions. The steels tested showed a coarse-grained crystalline structure, which, however, could be transformed to a finer-grained crystalline structure by suitable heat treatment. Heat treatment increased to a marked degree the static tensile strength, ductility, Brinell number, Charpy value, repeated-impact value, and the fatigue strength. The ratio of endurance limit to ultimate strength was found to average 0.42, which is slightly less than the average for ordinary rolled steel. It was concluded that under favorable casting conditions, and by the use of suitable heat treatment, cast steel can be produced having a strength under either static load or repeated load only slightly less than the strength of rolled steel of similar chemical composition.

Drain Tile. The Minnesota station has found that commercial concrete drain tile are subject to disintegration by the ordinary sulfate salts where found in the soil waters of the clay subsoils of the state in quantities exceeding about 0.15 per cent. The severity of action on concrete tile of pure solutions of sulfates of magnesium and sodium was found to be somewhat proportional to the strength of the solutions up to 1 per cent. Solutions of from 1 to 9 per cent did not greatly hasten the action.

ARTIFICIAL DRYING OF CROPS

The necessity for the artificial drying of hay and grain crops is becoming more and more apparent. Some work has therefore been undertaken to determine what procedure is necessary to dry a crop satisfactorily as a basis for the development of the necessary apparatus.

Corn. The Illinois station has found that for quick drying of corn and a minimum loss of grain, forced, heated air is the most effective. Very good results may also be secured with a well-designed crib and good natural ventilation provided by an aerator and some sort of ventilating ducts to draw the air through the corn. It has been found in general, however, that the drying of soft corn with forced, unheated air is a slow and costly process when the temperature is low and the humidity is high. Tests of the artificial curing of seed corn showed that the germination of the corn dried by 79.4 hr. of forced heated air at 93 deg. F. was not damaged. The seed dried by 207.6 hr. of forced, unheated air germinated 19.2 per cent below normal. The germination of seed which was allowed to dry by natural ventilation was injured to the extent of 18 per cent. The reduction of moisture in corn was the most rapid by use of forced, heated air, and the corn so dried was the only lot tested that was sufficiently dried so that below zero temperature in December had no injurious effect on the viability of the seed.

Hay and Grain in Stacks. The Indiana station found, in experiments on the drying of alfalfa and soy bean stacks, that evenness in building the stack is necessary. After four hours blowing of hot gases of combustion mixed with air into a 5-ton alfalfa stack, those parts which permitted the easy passage of air were dry clear to the outside, while the dense hay was still damp 30 in. from the outside. A 12-ton stack of soy bean hay was greatly overdried by 11 hr. of blowing. An 8-ton stack of soy beans was well dried by 5 hr. of blowing with the ingoing air at 150 deg. F. A heavy shower preceded the building of a 10-ton alfalfa stack from hay in the swath. This stack was blown 7.5 hr. with air at a temperature of 162 deg. F., and it dried in a patchy manner due to uneven building. However, when taken down two days later it was well fit for the mow.

Similar experiments at the University of Aberdeen in Scotland indicated that much is yet to be learned before the crops can be dried with certainty and economy by means of an artificial air blast. Apparently it is necessary first to learn more of the conditions under which heating takes place in stacks. It was found, for example, that damp oats did not heat much in stacks and such heating as did occur was very uneven. It was also found that stacks must be built so as to permit the air to pass freely through all parts. It is therefore necessary to provide the thinnest layer at the lower part of the stack owing to the greater pressure at that point. It was found further that the undried material absorbs rain readily, making it difficult to dry the head of the stack in unsettled weather. This makes under-cover drying desirable where possible. Experiments with three different stacks of hay using heated air at temperatures varying from a little less than 100 to over 130 deg. F. gave unsatisfactory results, primarily because the stacks were not fully dried. The fuel consumption was also high and would have been uneconomical even had the drying been successful.

Studies conducted by the University of Oxford in England on the artificial drying of crops in stack showed that the use of air at atmospheric temperature was a failure under adverse weather conditions. The use of air heated to 97 deg. F. at the rate of 2800 cu. ft. per min. was found practicable. It was also found that where there was sufficient heat and volume of air so regulated as to obtain the necessary heat reaction inside the material the drying was successful. Laboratory studies on the development of the drying apparatus showed that, with cylindrical and conical chambers, the slope of the center chamber did not influence the formation of eddy currents, if the blast of air was previously allowed to spread gradually in the duct without losing its stream line motion, and provided the velocity of the air was low. The penetrability of a stack was found to vary according to its height. The design of the center chamber was found to be influenced by the fact that the action of rapid drying caused a stack to consolidate quickly and decrease in height within a few hours. It was therefore necessary to design the center chamber so as to insure equal distribution of the air after consolidation had taken place. During the drying of sugar-beet cossettes, the resistance gradually decreased as the moisture content was reduced and the dried material had a resistance approximately equal to 25 per cent of that of the original wet material. The shrinkage during drying was approximately 50 per cent. Wet and dried cos-

settes were found to obey the same laws with regard to air velocity and thickness of material. Experiments with hay showed that to avoid undue resistance to the passage of air the average velocity of the air through the material should not exceed 20 ft. per min. This seems to definitely fix the size of the center chamber for a given mass of hay. It was further found that a temperature of 150 deg. F. with any quantity of moisture present will effectively kill germination in seeds, and a temperature of 140 deg. F. in the presence of moisture will greatly reduce germination, rendering the grain unfit for malting purposes. However, when a temperature of 120 deg. F. is reached in a moist state there is an increased speed of germination. Heating in a dry state appeared to cause little actual damage to seeds, aside from a slight retardation of germination. Owing to the cooling effect of evaporation a duct temperature of 140 deg. F. is considered safe for crops grown for seed.

It seems likely that considerable is yet to be learned of a basic nature with regard to rational crop drying. It is gratifying to note that work on the subject is tending to emphasize the fundamental features of the problem.

IRRIGATION

Outstanding results of a basic nature have again been established in different phases of the subject of irrigation.

Soil Moisture Capacity and Distribution. The California station has established the existence of a normal moisture capacity and a maximum moisture capacity in soils representing the minimum and maximum amounts of water retained by a soil when water is applied at the surface and is free to move downward through the soil mass. At normal capacity the soil water is readily available to plants but is not free to move under normal film forces, whereas at maximum capacity the water is free to move under film forces and its distribution is comparable to the upper portions of a capillary-rise distribution.

Increasing the size of sample reduced to a slight extent the amount of water retained in very coarse and very fine soils, according to the results of moisture equivalent studies conducted by the Utah station. Soils of intermediate texture showed greater effects, on the other hand. The moisture gradient in the soil mass opposing centrifugal force of the machine showed a similar maximum with soils of intermediate texture. Very fine-grained soils had a nearly uniform moisture distribution at equilibrium. A period of many hours contrifuging was often required to establish capillary equilibrium in the case of heavy clays and very fine silts. When samples of from 10 to 25 gm. were centrifuged, silt of about 10 microns average diameter retained more water than silt of 5 microns average diameter, this excess decreasing with increasing size of the sample. The very fine silts retained as much or more water than the heavy clay.

The Utah station also found that if the angle of contact of the surface of contact of water and soil grains is zero, a soil kept in a dark chamber can not be in equilibrium with saturated water vapor without becoming completely saturated with water. This appears to lead to a new interpretation of the so-called hygroscopic coefficient, in that it becomes a measure of the moisture condition at equilibrium between soil and water in the presence of light, but this moisture condition changes with the intensity of the light. Some experimental evidence has also been accumulated indicating that the angle of contact involves the curvature of the surface of separation of the liquid and solid phases. It is suspected that the surface tension heretofore regarded as a constant for a given liquid and a given solid may itself vary over a slight range for varying curvature.

Soil Moisture Movement and Distribution. The California station has obtained evidence that the extent of capillary rise through soil masses from a free water table is affected by the cross-sectional area of the column under consideration. In general, large columns showed a greater rise after a given time than small columns. The size of the container was of the greatest importance in columns with a cross-sectional area of less than 25 sq. in. There was no uniform distribution of moisture throughout the length of the capillary columns. A zone of maximum moisture content was found at an appreciable distance above the water table. There was some evidence that in columns of small cross-sectional areas the distance of this zone of maximum moisture content above the water level varies with the size of the column, this distance being greater as the columns become larger. It was found, however, that when the cross-sectional areas became greater than about 16 sq. in., further increases in size did not affect the relative position of this zone of maximum moisture content. There was a fairly uniform and consistent moisture content at all points in the same horizontal plane.

The Utah station found an increasing moisture content in soils from the surface down to the water table under equilibrium conditions, when studying the influence of the water table on the distribution of moisture in the soil layers above. The results indicated that there is a surface of saturation well above the water table under equilibrium conditions, and that this surface gets lower as the soil becomes coarser from clay to sand. Time is also an important factor in this connection.

Moisture Losses. The outstanding factors causing loss of moisture during the winter months from soils in the Waterville area were found by the Washington station to be snow drifting and loss of snow-water due to run-off from frozen soils. A tract not plowed and from which the stubble was burned in the fall had the lowest penetration of moisture. The loss by run-off where the stubble was left standing about equaled the loss by drifting from plowed soils.

Soil moisture losses from the upper 18 in. of soil were reduced to an appreciable extent by an asphalt-coated paper covering, according to results obtained by the California station. The paper covering also increased the mean temperature of the soil, hastened the time of warming, retarded the rate of cooling, and gave a narrower range between the maximum and minimum temperatures. The results were taken to indicate that while the use of the paper covering may conserve the moisture to some extent there is no indication that it will favorably affect the growth of crops.

In investigations of irrigation water requirements in the Sacramento Valley, the California station also found that as a general rule a considerable quantity of water is lost by deep percolation in areas served by cheap gravity water.

Duty of Water. The best duty of water for alfalfa was obtained from about 50 in. of water applied in 5-in. irrigations at the New Mexico station, and for wheat from about 15 to 20 in. applied in 4-in. irrigations. The duty for miscellaneous crops varied widely with the crop, and the yields of most of the crops seemed to be more closely correlated with the amount of water applied than with the soil type. The yield of alfalfa per acre-inch decreased with the amount of water applied.

The Oregon station reported that the best results were secured from 12 to 14 acre-inches per season for cereals, 18 to 20 for alfalfa, 18 for clover, 30 for Mammoth Russian sunflowers, 14 to 16 for field peas, 18 for peas and oats, 10 for potatoes, and 12 acre-inches for beets and mangels.

Time of Irrigation. The Washington station found in fall irrigation experiments that the yields from alfalfa plats did not show noticeable increases or decreases due to fall irrigation. However, the corn plats, which were not irrigated in the fall and were irrigated in the spring before planting, produced an average yield of 61.5 bu. per acre as against an average of 49.8 bu. per acre for the plats which were fall irrigated and not spring irrigated.

Irrigation Methods. The results of studies by the New Mexico station indicated that shorter lengths of plats with a small irrigation head required about one-fourth less water to produce about 10 per cent less alfalfa than longer plats. From the standpoint of the water used about 12 per cent more alfalfa could be produced per acre-inch on the shorter plats than on the longer plats.

The Oregon station reported that irrigation borders should be constructed from 30 to 40 ft. wide and from 150 to 200 ft. long, depending upon the head of water available, the character of the soil, and the topography of the land. Tests to determine the economical application of water to sandy soil types without loss from percolation showed that the coarser types should not be irrigated with more than 3 in. of water, the medium types with not more than 4 in., and the finer types with not more than 5 in. for each application.

The California station showed that contour irrigation is

the best method to use when straight furrow irrigation causes washing and when the soil is shallow and irregular. Where properly followed, this method has been found to increase the penetration of irrigation water and to conserve and control storm water.

Well Capacities. The values of the specific capacities for dug irrigation wells were found by the Montana station to vary from 0.037 to 0.39 cu. ft. per sec. per ft. of draw-down. Those for the drilled wells varied from 0.022 to 1.04. The results indicated that for practical irrigation wells there is no apparent definite relation between the amount of water a well will yield and its diameter. For a given well there is a definite relation between yield and the draw-down. The results did not indicate that in new pumping districts dug wells of large diameter will give a greater yield than drilled wells. It was found further that the greater the total thickness of the water-bearing strata penetrated by a well, the larger will be the yield for a given draw-down. It is for this reason that wells of large capacity are frequently drilled several hundred feet deep, although the water table may stand within a few feet of the surface. When wells are drilled where the water-bearing strata are not encountered until the shaft has been sunk rather deep, the water usually rises in the shaft above the point where the water-bearing stratum was first touched.

Well Drilling. The Arizona station reported the development of the so-called stovepipe method of well drilling to meet the conditions of the state. In this method the drilling is done with a mud scow, using the stovepipe casing which is forced down with hydraulic jacks. The mud scow is a drilling tool similar to the ordinary sand bucket but is made extra heavy and is equipped with a heavy steel cutting shoe. It serves both as a drilling tool and as a bailer for cleaning out the hole.

Irrigation Structures. The Colorado station conducted preliminary tests of a double-hump hydraulic jump flume with the idea of increasing the degree of submergence before interference with the free flow. This arrangement did not show any marked improvement over the improved Venturi flume.

The above typical results of work in irrigation indicate a growing tendency on the part of engineers to learn more of the underlying principles involved in the use of water for irrigation. The fact that the rational use of irrigation water is definitely related to certain hydraulic properties of soils seems to be more or less generally recognized

DRAINAGE

The investigational work in drainage does not appear to have progressed as it perhaps should. It is being recognized in some quarters, principally by soil technologists, that the principles of soil hydraulics must be considered to a greater or lesser extent before the principles of underdrainage can be thoroughly elaborated. Agricultural engineers seem to have been perhaps a little slow to recognize this fact and to take advantage of the cooperation offered by soil technologists. However, some work has been undertaken which indicates some of the general aspects of the soil-drainage problem.

Ground Water Level. Observations of ground-water fluctuation by the California station showed that the water table in the Kearney vineyard reached a point nearest the surface during June and during most of the year was well within the ideal root zone of plants. The seasonal fluctuation of the water table was found to be between 5 and 6 ft., and the most rapid rise occurred during March and April. As the season progressed the rate of rise was much less than in the early spring.

The Michigan station found that a considerable difference may exist in the moisture content of the well-drained sandy soils of the state, which may at certain times be as low as 1.5 per cent in certain horizons of the Grayling sand. The water content of all the soil types studied was found to be fairly constant at depths of from 3 to 5 ft. and very little of the summer precipitation penetrated to these depths. The greatest fluctuation in the water content appeared to be in the surface horizon.

The Michigan station also found that, generally, when the water level in muck soils averages a depth of four or more feet during the growing season, lower crop yields are secured than when it is at a less depth. For most crops a water level averaging around 3 feet has been found to give the best results, while for some, notably celery, a lesser depth will produce higher yields.

Soil Moisture Movement. Laboratory studies of percolation movements through natural soil cylinders 5 in. in diameter by the Missouri station showed that, when the natural cylinder was allowed to become air-dry before applying certain chemical treatments, the rate of percolation was greatly increased. More consistent results were obtained when small cylinders were filled with carefully graded dry granulated samples of the same clay.

The Wisconsin station found that the penetration of moisture into cultivated corn soils 24 hr. after a 0.58-in. rain was into the 12 to 18-in. depth of medium sand, but was almost wholly confined to the 6-in. depths of fine sand and sandy loam. Eight days after the rain its effect in the medium and fine sands disappeared, but was evident at the 18 to 36-in. depth of sandy loam. It seems quite evident that something more than the laying of tile drains must be undertaken before the underdrainage of soils is placed on a satisfactory and economical basis.

SANITATION

Some work has been continued on sewage disposal and water supply.

Sewage Disposal. In a continuation of studies of the factors affecting the design of farm septic tanks, the Illinois station found that considerable improvement in the purification of effluent was obtained by adding another chamber to still further treat the effluent from a given preceding chamber. Curves of turbidity, residue on evaporation, and settleable solids platted against time showed erratic results in the small chambers of the three-chamber tank. This was due to the fact that the first chamber fills up and then discharges considerable amounts of floc at one time, thus producing a variation in the quality of the effluent. The results as a whole were taken to indicate that a two-chamber tank is more efficient than a three-chamber or a single-chamber tank of equal size under the conditions encountered and with the size of tanks studied.

The West Virginia station conducted a study of sanitary conditions in three counties of the state, which emphasized the need of adequate and safe methods of disposing of farm home wastes. The percentage of outdoor closets on farms that could be passed as sanitary was extremely low. On 124 of the 287 farms visited, the open-back privy was in use, 90 others were built on the surface but were closed in the rear, and on 21 farms there were no privies at all. No septic-tank privies were found, and only 44 of the 287 farms had pit privies. Where bath equipment was found the effluent was either drained out on the surface of a field or into a nearby creek. No septic tanks were found, although the need for them was apparent.

All three classes of protozoa were represented in the fauna of the Imhoff tanks under investigation by the New Jersey stations. Rhizopods were found to be fewest in genera and numbers and flagellates the most numerous. About seventy species of protozoa were encountered with some frequency, the common forms being either facultative or obligatory anaerobes. Some of the protozoa were found to come into the tanks in the free-living state and some in the encysted form. Not all of those carried in live, and some of the encysted forms do not excyst.

Fluctuations in the carbon-dioxide content of gas from one of the tanks were found to be more or less of an oscillatory character. The oscillations themselves were independent of temperature and were correlated in general with the resting and operating periods of the tanks. Shortly after a tank was put out of operation the carbon-dioxide content of the gas decreased. The direct relation between ammonia and carbonates produced with the H-ion concentration was very striking. The temperature of the tank contents varied with the seasonal changes, but the changes were very gradual. There was a fairly definite relation between ripe sludge and incoming fresh solids for rapid and efficient digestion, and the digestion processes in a storage tank reached equilibrium rather rapidly after partly digested material was added.

The manner of operating tanks influenced the general bacterial flora, and seasonal effects were obscured by short-time variations. The different groups of bacteria showed marked fluctuations. Fluctuations were found in the weekly accumulation of film on sprinkling filter beds. The texture of the film from tiles left in place for a considerable time had an outer layer composed of a whitish zooglea which adhered to the thin and crustlike middle layer. The inner layer was black with decayed material. The older film had more varieties of organisms, but apparently only the outer layer was habitable for most of the animals. There was no great difference between the numbers of animals in the old and new films. It was found that when fungi attained their largest volume the protozoa are fewest, and vice versa.

The general courses of digestion of fresh solids under aerobic and anaerobic conditions were similar, but the types of digestion were different. Under the anaerobic conditions the solid organic materials were transformed into liquid organic materials, whereas under aerobic conditions more of the organic material was gasified. The rate of digestion was also dissimilar under the two conditions.

Hydrogen was not found in the gases evolved by tanks. Hydrogen left in contact with sludge disappeared rapidly. Practically no hydrogen was absorbed when the sludge was sterilized. Material stirred every day did not advance more rapidly than material which was stirred only twice during an incubation period of two months. The material stirred once a week seemed to be in the best condition. The addition of an alkali or an alkaline salt was found to cause the solids to settle to the bottom of the tank, so that digestion proceeded more rapidly. Calcium chloride served the same purpose.

Copper sulfate and mercuric chloride in concentrations varying from 1 to 100,000 to 1 to 1,000,000 depressed the numbers of protozoa and stimulated the numbers of bacteria. Paratoluidine in a concentration of 1 to 1,000 killed off all protozoa, and in a concentration of 1 to 10,000 greatly suppressed their numbers. Lime in concentrations of 1 to 750 and 1 to 1,000 killed all protozoa within 24 hr. When fresh solids were added, making the mixtures less alkaline, the protozoa were markedly stimulated. Carbon disulfide emulsion in concentrations varying from 1 to 1,000 to 1 to 5,000 killed off all protozoa and suppressed their growth for over a month. Even at lower concentrations their numbers were greatly reduced, but in a concentration of 1 to 15,000 there was a marked stimulation of the numbers of protozoa after one week.

Water Supply. The West Virginia station found in a study of sanitary conditions in three counties of the state that 66 of 287 farms visited could have had running water in the house by merely piping the water direct, but only 33 were planning any sort of installation. Dug wells were found to be the most common source of water on the 287 farms, and springs furnished the supply on a large number. Cisterns seemed to be growing in popularity. Not enough attention was being paid to proper filtration of the cistern water that was used for drinking purposes, however.

LAND CLEARING

The work in land clearing has tended in several different directions, for the most part being practical demonstrations of the use of available knowledge.

Pine Stump Fuels. For example, the cordwood production from nine experimental plats of pine stumps ranged from 3.13 to 16.88 cords per acre, with an average of 9.74 cords, according to the Minnesota station. It required 10 hr. to blast an acre of stumps and 2.8 days of man labor and 3 days of horse labor to assemble the stump fragments for sawing. It required 65 lb. of explosive to stump an average acre. Much of the stump material required splitting or blasting before sawing. About 1.75 hr. of one man's time, nearly 0.75 hr. of tractor time, and a trifle over 0.25 lb. of explosive were required to saw one cord of stump wood fuel. The total cost, including clearing, of a cord of stump wood fuel, tightly piled, was found to be about $4. This included labor 57 per cent, blasting material 31 per cent, and power 12 per cent.

Cost of Stump Removal. The Alabama station found that when the cost of explosive is the same per pound the final cost of removal per stump is not in proportion to the diameter. The cost per stump was nearly doubled for each increase of 3 in. in diameter.

Soil Conditions and Blasting Efficiency. Where soil is loose, friable, and soft and has a low free-water content, the blast is forced into the earth by a heavy-rooted hardwood stump, according to experiments by the Alabama station. An extra large charge will heave the soil through the roots and leave the stump intact, indicating that the force of the blast compresses the soil upon the bottom and sides of the shot hole. The result is that the line of least resistance is upward. With a high free-water content in the soil, the blast was found to meet positive resistance upon the bottom and sides of the shot hole, owing to the fact that the free water rendered the soil less compressible. The line of expansion of the blast is upward after a relatively small downward and lateral expansion. Instead of soil working through the roots as with drier soils, it holds together and acts as a shoulder for the force of the blast to lift against.

Explosives. Twenty per cent ammonia dynamite with a speed of 9,600 ft. per sec. was found by the Alabama station to be too slow for stump blasting in dry soils. It blew the dirt from under the stump leaving it in place and difficult to remove. Sixty per cent dynamite with a speed of 16,000 ft. per sec. was more satisfactory, but was too fast, since it shattered the stump without removing it. The most satisfactory explosives were the 30 and 40 per cent dynamites having speeds of 12,000 and 14,000 ft. per sec., respectively. All of the above explosives were satisfactory in wet soils. There was little or no difference in performance of the high counts of 30 and 40 per cent dynamites. It was found that for green hardwood stumps in bottom soils having a relatively high free-water content the load in pounds of high-count dynamite required is equal to the square of the diameter of the stump in feet 14 in. from the ground plus 0.5.

Stump Burners. The California station developed two kinds of stoves for burning stumps. The so-called California stove is a return-flue type which burns the stump from the inside by first burning a hole in the stump, thus causing it to become its own stove. Redwood was found to be the most difficult type of stump to burn. The barrel-type stove was developed for hardwood stumps. The process involved requires that the roots be blasted out and the stump split sufficiently to cause it to dry. It is then burned out with a can over the top. The cost of clearing land of oak stumps from 6 to 18 in. in diameter with this method was considerably less than with the pulling method. Green or wet stumps opened with a light powder blast in the winter or spring were found to burn readily the following fall. It was not necessary to blast softwood stumps, and such stumps could be burned from 5 to 6 ft. below the ground. Green or wet hard wood stumps could not be burned below the tillage depth.

CONCLUSION

Obviously the above review is not complete. It is indicative, however, of the type of work done during the year in or bearing on agricultural engineering. There is evidence that the amount of creditable investigation in the subject is increasing. There is tendency toward the redevelopment of points of view in agricultural engineers from the general and superficial to the specific and fundamental. This mental transformation is slow as yet, but it is gradually being forced by the demands for more efficient and economical agricultural production. There is evidence that rule-of-thumb procedure to cover all similar cases is being gradually replaced by carefully thought out and scientifically sound procedure for each individual case. The work of the different technical divisions of the American Society of Agricultural Engineers has obviously been instrumental in this connection, and the present work of the U.S.D.A. Advisory Council on Research in Mechanical Farm Equipment seems likely to strengthen the situation materially. As a whole, the research situation in agricultural engineering is beginning to show an element of promise.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture

Effect of Temperature on Sewage Sludge Digestion, W. Rudolfs, (Industrial and Engineering Chemistry, 19 (1927), No. 2, pp. 241-243, fig. 3).—Studies conducted at the New Jersey Experiment Station are briefly reported which showed that digestion of sewage sludge is extremely slow at temperatures below 10 deg. C. Raising the temperature a few degrees above 10 has comparatively little effect, but the digestion time is materially decreased with higher temperatures. The maximum digestion was found to take place at about 27-28 deg. C. Definite quantities of organic material present in sewage were found to produce about the same volume of gas at all temperatures. The volume of gas produced from the same sewage sludge can be increased by changing the reaction of the medium and the composition of the gas, which is due to a preponderance of different organisms.

It was found that in a given time the average number of bacteria per gram of organic matter in unadjusted sludge does not increase with an increase in temperature, whereas the average numbers of bacteria in sludge treated with lime decrease with the increase in temperature. In the same given time the numbers of protozoa follow the bacterial numbers.

The time of digestion was found to be further decreased by maintaining a proper reaction in the material corresponding to pH of from 7.3 to 7.6. The composition of the gas changes with the reaction of the medium.

Acids in Automatic Crankcases, A. F. Meston (Industrial and Engineering Chemistry, 19 (1927), No. 2, pp. 312-315, fig. 2).—Studies are reported which showed that an acid condition is always present in an automobile crankcase. Acids were found in the lubricating oil, in the diluents in the oil, and in the vapors escaping from the crankcase. Some of the acids were more soluble in water than in oil, and some were corrosive. Positive tests for naphthenic acids were obtained with oils, diluents, and condensed water vapors. The neutralization value of a crankcase oil apparently reaches a maximum after the oil has been in service for several hundred miles of operation. The presence of sulfur is noted, and data are presented relating to its distribution in the various liquids and vapors.

The Combined Reaper-Thresher in Western Canada, J. K. Mackenzie (Canada Department of Agriculture Pamphlet 83, n. ser. (1927), p. 14, fig. 10).—The results of experiments at the Dominion Experimental Station, Swift Current, Sask., are reported, together with the results of a survey of the experience of owners of combines.

The general conclusion is drawn that the minimum acreage for which a combine is purchased should not be less than 300 acres unless the purchaser intends to do custom work. The maximum acreage for a combine in one season can not safely be placed above 800 to 1,000 acres.

The waiting period between binder harvesting and combine harvesting may vary from eight to twenty days, depending on climatic conditions. With Marquis wheat there was found to be usually very little additional loss from shelling by waiting until the proper time to harvest with the combine. Any loss sustained is generally offset by the smaller loss incurred in handling the crop with the combine. It was found that wheat damaged by the sawfly can be picked up as well by the combine as by the binder. The only apparent cause of loss from using the combine is in the case of a thin crop infested with green weeds.

It was further found that a heavy crop flattened out by storms can be harvested more easily by the combine than by the binder. By traveling slowly, overloading of the threshing mechanism can be avoided. In general a bad season for the combine is also a bad season for the binder and separator. Following a rain the combine can be started sooner than the separator.

Combines in Illinois, E. W. Lehmann and I. P. Blauser (Illinois Station Circular 316 (1927), p. 16, fig. 5).—The results of investigations of the use of combines in Illinois for threshing are presented.

The results of twenty-four tests in harvesting soy beans with the combine showed an average total loss of only 8.89 per cent, which included the loss back of the cutter bar as well as the loss from the threshing and separating parts of the combine. The wheat losses were reduced one-third by the use of the combine, and this machine appeared to be superior to any other for harvesting sweet clover seed. The most common size of tractor used to pull the combine in Illinois is the 15-30 hp. It has been found that for successful use of the combine and in order to produce grain with a low moisture content the grain must stand from seven to ten days longer than when cut with a binder. Losses back of the cutter bar are reported as being the heaviest ones in harvesting soy beans with the combine. The amount of loss depends upon the amount of lodging, the height of cut, and the height of the lowest pods on the stems. With a properly adjusted combine on level ground it was found possible to cut as low as 4 in. above the ground. This sometimes made necessary the use of a special low-cutting type of cutter bar.

Weeds were found to cause some trouble especially if they were tall and the soy beans short, since the reel must be set low enough to get the beans and it also gets the weeds. The bar type of cylinder was found to meet the difficulty with bull nettles a little better than the tooth cylinder because the bar cylinder does not mash as many of the berries. Weeds and sweet clover as high as the wheat also cussed serious trouble in harvesting small grain because of the difficulty of removing the broken stems from the grain.

It was found that the cylinder speed must be reduced to about one-half of that for threshing small grain to prevent the splitting of soy beans and at the same time the other parts of the machine should be run at rated speed.

Sweet clover was found to give some trouble in harvesting with the combine because the platform canvas does not readily carry the material. One or two extra men must be kept back of the platform to force the material down into the machine with heavy brooms. The combines with a separate motor gave better results with sweet clover than those driven by a power take-off.

Effect of Moisture on Electrical Properties of Insulating Waxes, Resins, and Bitumens, J. A. Lee and H. H. Lowry (Industrial and Engineering Chemistry, 19 (1927), No. 2, pp. 302-306).—Studies are reported in which measurements of the dielectric constant and effective conductivity at one thousand cycles and resistivity were made on thirty-one waxes, resins, and bitumens. These materials included not only natural products but commercial dielectrics and mixtures. The measurements were taken for the initial thoroughly dry condition, after six months' immersion in a salt solution corresponding qualitatively to exposure to ninety-eight per cent relative humidity, and after having been redried.

All of the insulating materials studied absorbed water under the conditions of the experiment. The absorption was least with the hydrocarbons and greatest with shellac and bayberry wax. In general the greatest increase in capacity and conductivity and the greatest decrease in resistivity were shown by the materials which absorbed the most water. The percentage change was much greater in the conductivity and resistivity than in the dielectric constant.

A Comparison of the Direct Measurement of the Heat Production of Cattle with the Computation of the Heat Production by the Respiratory-Quotient Method, E. B. Forbes, M. Kriss, W. B. Braman, and R. B. French (Journal of Agricultural Research [U. S.], 34 (1927), No. 9, pp. 865-878).—Studies conducted at the Pennsylvania Experiment Station are reported which showed that the computation of the heat production of cattle by the respiratory-quotient method, as modified by either Andersen or Krogh on account of the extensive fermentation of carbohydrates in the ruminant alimentary tract, gives results which agree very well with direct heat measurements.

In spite of the fact that the procedure followed in the indirect method was imperfect in a number of details, in eighteen comparisons with the direct method all of the computed values were between 98 and 104.8 per cent of the directly observed values.

Andersen's and Krogh's methods of computation of the heat production of cattle, while somewhat different in theory and while yielding respiratory quotients differing in magnitude and in significance, yield virtually identical values for heat production.

Eighteen determinations of the computed heat production, according to Andersen, divided by the directly observed heat production, differed from a similar value involving Krogh's method by 0.1 to 0.4 per cent, the average being 0.24 per cent.

In view of the variability in the composition of the outcoming air from the respiration chamber, as determined in samples taken at half-hour intervals, and as affected especially (a) by the position of the animal as to standing or lying, (b) by the activity of the animal, (c) by the time elapsed since change of position, and (d) by the time elapsed since feeding, no short-time period of observation can be assumed accurately to represent the whole day. The products of the extensive fermentation of carbohydrates constitute an important factor in this variation.

Electricity on New England Farms. W. T. Ackerman (New Hampshire Station Bulletin 228 (1927), pp. 47, fig. 10).—This is a progress report for the years 1925-1926 of the project at the station on the relation of electricity to agriculture. It presents the results of experiments on the use of both major and minor electrical equipment on seven farms in New Hampshire, representing dairy, poultry, fruit, and general farming.

Current consumption on the seven farms average 1,683 kw-hr. for the year 1925 and increased to 4,253 kw-hr. in 1926. Heating equipment, such as refrigeration, ranges, ironers, water heaters, etc., produced the greatest effect on the total consumption and developed a peak load in midsummer. The total consumption for the year 1926 was distributed as follows: Winter, 23 per cent;

spring, 16; summer, 32; and fall, 28. The total consumption by farms for 1926 ranged from 432 kw-hr. for the fruit farm to 7,694 kw-hr. for one of the dairy farms.

House lights showed an average monthly consumption of 34.6 kw-hr. ranging from 15.2 to 63.3; water pumps 23.7 kw-hr. ranging from 3.7 to 39; and kitchen ranges 167 kw-hr. ranging from 26 to 282. House refrigerators used an average of 35.3 kw-hr. per month, ranging from 23 to 39.5; and hot water heaters 182 kw-hr., ranging from 15.2 to 548. The latter have given a high degree of service, but their cost of operation has been high. Washing machines used an average of 2.6 kw-hr. per month, flatirons 7.3 kw-hr., and ironing machines 12.7. Barn lights used an average of 7.9 kw-hr. per month, ranging from 4.3 to 13.9; and milking machines 91.5 kw-hr., ranging from 56.5 to 134. Dairy cooling rooms showed an average monthly consumption of 119 kw-hr., ranging from 96.5 to 148.

Harvesting Wheat with a Combine Harvester-Thresher in the Great Plains Region, 1926, R. S. Kifer, W. R. Humphries, and J. H. Martin (U. S. Department of Agriculture 1927, pp. 26, fig. 1).—The results of a cooperative study by the Bureaus of Public Roads, Agricultural Economics, and Plant Industry with the Texas, Oklahoma, Nebraska, and Montana Experiment Stations of the use of the combine are reported.

The combine has been found to give general satisfaction in harvesting wheat in the region. The advantages found are that it lowers the cost of harvesting and threshing, reduces the amount of labor required, and shortens the harvesting and threshing period. It was found that grain cut annually by combines of all types and sizes averaged 553 acres per machine. The capacity of the machine is primarily dependent upon the width of cut and the length of the harvest season.

The more important elements of cost for harvesting with a combine were charges for labor, fuel, repairs, depreciation, and interest on the investment. For all combines the depreciation averaged 44 cts. per acre. There was no apparent relation between the acres cut annually and the estimated life of the machine. The per-acre depreciation charge was less for large than for small acreages cut by the same size of machine.

For small acreages the expense of harvesting with a combine was greater than for either a binder or header. Where only the usual direct costs are considered, 100 acres could be harvested as cheaply with a binder or header as with a small combine. The average harvesting loss with combines was found to be 2.6 per cent of the total yield, as compared with 3.3 per cent for a header and 6.1 per cent for a binder.

Irrigation Investigations at the New Mexico Station (New Mexico Station Report 1926, pp. 19-24).—The progress results of investigations conducted in cooperation with the U.S.D.A. Bureau of Public Roads relating to ground water movement, duty of water, and water requirements of crops are briefly reported, and some of the more important data are tabulated, particularly on duty of water.

Run-off Water Losses in Relation to Crop Production (Texas Station Report 1926, pp. 42, 43).—In a progress report of this work it is stated that the results thus far indicate that a large amount of water is lost by run-off from Texas soils, and that the intensity of the rainfall, the percentage of water in the soil, the condition of the soil, the crop on the land, and the type of obstruction are all important factors in this connection.

Sewage Disposal for Suburban and Country Homes (Virginia Health Bulletin, 17 (1925), No. 6 (rev.), pp. 39, figs. 28).—Practical information on the planning and construction of sewage disposal systems for suburban and rural homes adapted especially for conditions in the State of Virginia is presented.

Federal Irrigation Projects (Washington: U. S. Department of Interior, Bureau of Reclamation, 1926, pp. 50, figs. 30).—General information is given regarding the irrigation projects of the U. S. Bureau of Reclamation.

Selected List of Government Publications on Housing and Equipment, compiled by R. Van Deman (U. S. Department of Agriculture, Bureau of Home Economics, Home Economics Bibliography 2 (1927), pp. 15).—An annotated list of 75 publications is given.

Manufacture and Sale of Farm Equipment, 1925 (Washington: [U. S.] Bureau of the Census, 1927, pp. II + 13).—Statistical data on the production and sale of farm equipment in the United States during 1925 are presented in tabular form. The total value of farm equipment manufactured in 1925 showed an increase of 21.4 per cent over the 1924 production and of 7.6 per cent over the 1923 production. Increases were shown for 1925 for 9 of the eleven groups of equipment, the exceptions being harvesting machinery and haying machinery, which showed decreases of 4.6 and 2 per cent, respectively, from the previous year.

Design and Control of Concrete Mixtures (Chicago: Portland Cement Assoc., [1927], 2. ed., rev. and enl., pp. 32, figs. 19).—This is the second edition of this book, which deals with the design of concrete mixtures. It includes a general statement of the factors essential to the economic production of concrete of proper strength and durability. Particular emphasis is placed on the selection of materials, the mixing and placing of concrete, protection during curing, and the importance of proper workability.

Agricultural Engineering Studies at the Missouri Station, J. C. Wooley Et Al. (Missouri Station Bulletin 244 (1926), pp. 21-24, figs. 2).—The progress results of investigations of sanitary conditions on farms, of method of prolonging the service of wood fence posts, of tile draining Missouri soils, and of clearing cut-over lands are presented. Some of the more important results indicated that in general the most effective treatments for wood fence posts were the double tank treatments of creosote. Willow was more favorably affected by treatment than was cottonwood. Data are also briefly reported on the cost of power for operating electrically driven milking machines.

Effect of Pumping from Deep Wells on the Ground-Water Table, W. W. Weir (Journal Agricultural Research [U. S.], 34 (1927), No. 7, pp. 663-672, figs. 10).—Studies conducted at the California Experiment Station are reported which dealt primarily with pumping in the San Joaquin Valley.

The results indicated that effective drainage can be obtained for a distance of more than one thousand feet from the pump. In order to maintain a constant depth of water table, it is necessary to keep the pump in continuous operation during the pumping season. There was found to be a rapid movement of water through the water-bearing sands and gravels of the region, as evidenced by the rapid recovery of the water table to normal when the pumping was stopped. For increased effectiveness in lowering the water table and thereby providing drainage and in supplying water for irrigation, it is considered likely that pumps of larger capacity than the one used in the experiments may be installed without either creating an uneconomical lift or bringing about a significant diminution of the water supply.

Ropework for the Farm: Useful Knots, Hitches, and Splices, J. M. Smith (Alberta University, College of Agriculture Bulletin 9, 2, ed. (1927), pp. 36, figs. 64).—This is the second edition of this publication. It contains sections on essential knots and hitches, useful knots and hitches, splicing, halters, finishing the ends of rope, emergency halters, and casting cattle.

Tests of the Fatigue Strength of Cast Steel, H. F. Moore (Illinois University Engineering Experiment Station Bulletin 156 (1926), pp. 20, figs. 8).—Studies of the strength of cast steel as a material and of the effective strength of this material in different parts of the casting, modified by internal strains, minute cracks, and foreign inclusions, are reported.

As cast, the steels tested showed a coarse-grained crystalline structure, which could be transformed to a finer grained crystalline structure by suitable heat treatment. The result of such heat treatment was to increase to a marked degree the static tensile strength, ductility, Brinell number, Charpy value, repeated impact value, and the fatigue strength of the cast steels. The ratio of endurance limit to ultimate strength was found to average 0.42, which is slightly less than the average value for ordinary rolled steel.

These results are taken to indicate that, under favorable casting conditions and by the use of suitable heat treatment, cast steel can be produced having a strength under either static load or repeated load only slightly less than the strength of rolled steel of similar chemical composition.

Some Chemical Characteristics of Sewage Sludge, S. L. Neave and A. M. Buswell (Industrial and Engineering Chemistry, 19 (1927), No. 2, pp. 233, 234, fig. 1).—In a contribution from the Illinois State Water Survey Division, data on the chemical characteristics of sewage sludge are presented which include such factors as volatile matter, fixed carbon, grease, nitrogen, carbohydrates and peptization.

Domestic Smoke and Atmospheric Pollution, H. Osborne (Medical Officer, 36 (1926), No. 26, pp. 293-295, fig. 1).—The results of experiments with open fireplaces bearing on the prevention of atmospheric pollution with smoke are briefly summarized. A comparison was made of the efficiency of ordinary house coal and dry gas coke from vertical retorts, and the tests were conducted in two rooms of similar size and shape and having identical all-fire brick grates.

It was found that the average temperature of the room in which a dry coke was used as fuel was slightly in excess of that supplied with coal. The average daily consumption of dry coke was 14.8 lbs., while that of coal was 21.8 lbs. In effect, to produce the same heating results the weight of dry coke required was roughly two-thirds of that of coal, and the coke gave a radiant fire and no smoke or sulfur fumes. The conclusion was drawn that by burning vertical dry coke in the all-fire brick well grate atmospheric pollution is eliminated and considerable economy effected. As compared with coal, the coke fires begin to warm the room much more quickly and the heat radiation is maintained at a high level for prolonged periods. A much greater proportion of the total heat of combustion is radiated into the room.

Running Water in the Farm Home, M. R. Lewis (Idaho Agricultural College Extension Bulletin 66 (1926), pp. 15, figs. 6).—Practical information on the planning and installation of water supply systems for farm homes is presented. It is pointed out that in most parts of Idaho good water may be obtained from underground sources. While shallow wells are satisfactory if carefully located and protected, the deep wells have been found to supply the safest drinking water.

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The Montreal Epidemic

THE recent outbreak of typhoid fever in the city of Montreal was a tragedy which agricultural engineers may well look into. According to the report of a special board of inquiry of the U. S. Public Health Service, the official records of the city showed 4,755 cases of typhoid fever, with 453 deaths for the period from March 1 to June 28, 1927. This was characterized as a case incidence in proportion to population probably unprecedented by any other large city in the world within the present century.

Apparently no evidence was obtained to suggest that either the city water supply or the city sewerage system operated in the spread of the infection causing the epidemic. The evidence did indicate, however, that the epidemic was caused beyond reasonable doubt by infection distributed in the output of milk from the plant of a certain dairy in Montreal which reached a large number of persons in different parts of the city at the same time. It appeared that at least three-fourths of the cases in the epidemic were in persons who were knowingly exposed to the milk output from this dairy.

The evidence showed further that, although contributory infection may have been introduced into the milk after it reached the dairy, the bulk of the infection was introduced into the milk at the farm sources. The milk supply distributed by this dairy was obtained from 1,200 to 1,500 farms. The families on these farms average large. The farms as a rule are small and dwellings along the highways for long stretches are close together. It was estimated that the milk from the farms supplying this dairy was exposed more or less to a population of 20,000.

The average dairy farm in this general vicinity was found to present unsatisfactory sanitary conditions. Open privies and open wells are frequent. In much of the country there is a limestone formation outcropping at or near the ground surface. Milk house doors are in many instances within a few feet of kitchen doors. Surface streams are used quite commonly as sources of water for the milk houses and also for the disposal of sewage from homes upstream. Surface stream water was also found in use for washing the interior of the milk cooling vats and other equipment at one of the milk-receiving stations used by this dairy in the country. The stream was obviously polluted with sewage and privy contents at numerous points upstream from and near the intake of the water.

Any special comment on these outstanding features of the report of the special board of inquiry seems superfluous. The further indication that a considerable proportion of the raw milk entering the dairy escaped efficient pasteurization is only an additional item in what appears to have been a terrible state of affairs.

It is hard to believe that such conditions are allowed to exist in prosperous farming communities in this presumably enlightened age. Nevertheless they do seem to exist and this fact is a challenge to local government officials everywhere to take notice and act.

Apparently the Province of Quebec has overlooked the fact that it numbers in its citizenry agricultural engineers, such as Heimpel at Macdonald College, for instance, whose business it is to know how to prevent the occurrence of or to correct the unsanitary conditions on farms which lead to such disasters. Provision for the proper education of the dairy farmers in the locality in question by extension agricultural engineers might have partially or even wholly averted this disastrous epidemic.

What happened in the Province of Quebec may also happen in the states. Agricultural engineers are in a position to aid materially in preventing the occurrence of such disasters if they are given the opportunity and authority to act. This fact should be forcibly brought to the attention of the proper state and other officials everywhere.

R. W. TRULLINGER.

"United We Stand—"

BECAUSE the entomologists, agronomists, agricultural engineers, manufacturers, and farmers presented a united front to the onslaughts of the European corn borer, the result of his attack on American agriculture is not nearly so disastrous as it might have been. It is true that he has penetrated the lines established to hold him in check, and it is true that he will no doubt eventually spread throughout the corn belt, but the control forces know now that it is possible to hold him in check to such an extent that commercial damage will be reduced to a minimum.

The result of the 1927 clean-up campaign is a splendid tribute to the control forces. The outstanding factor which contributed to this result is the fine example of cooperation that has been set by all groups participating in the control work. No such cooperation has ever before been manifest in a campaign of a similar kind, and, considering the handicaps with which the control forces were faced this year, the result of their efforts is amazing.

One feature of the corn borer clean-up campaign should be gratifying to the profession which this journal represents, and that is the opportunity which the corn borer invasion has given the agricultural engineer to demonstrate his proper place in the solution of agricultural problems, and particularly the contribution that members of the Society have made to this effort. The corn borer has done a great deal to advance agricultural engineering, mainly because agricultural engineers were alert to the seriousness of the situation confronting American agriculture, as a result of the borer. It is due in large measure to their vision and ability to meet the situation that effective means of control have been developed. To members of the Society connected with both federal and state institutions and with manufacturing organizations belongs most of the credit for progress in the control of the borer by mechanical means.

The campaign, however, has only just begun. Much remains to be done in the way of research and development of new equipment and new methods to meet the situation created by the corn borer. In this work the agricultural engineer will play a leading role. He cannot, however, do the job alone. His success is dependent on close cooperation with other groups. It is the united front presented by all groups that will finally seal the victory over this pest.

On another page in this issue will be found a report of the third annual corn borer conference. In the November issue will appear the report of a joint committee of entomologists, agronomists and agricultural engineers recommending future activities for corn borer control.

A. S. A. E. and Related Activities

Structures Division Meeting

WHAT will undoubtedly be the most important meeting ever held dealing with the development and improvement in farm buildings and other structures is the meeting of the Structures Division of the American Society of Agricultural Engineers to be held at Hotel Sherman, Chicago, December 1 and 2. The program as planned for the meeting is under the direct supervision of the chairman of the Division, W. G. Kaiser, agricultural engineer, Portland Cement Association.

The opening session of the meeting on the forenoon of December 1 will be devoted to the farm home. It will include a paper, entitled "Planning Farm Houses for Efficient Housekeeping," by W. A. Foster, associate professor of rural architecture, University of Illinois. Other subjects to be presented at this session, speakers for which have not been announced, are (1) the evolution of the American farm home and (2) the combining of beauty and utility in the farm home.

The afternoon session of December 1 will be devoted primarily to the subject of research in farm structures. The feature of the session will be a paper, entitled "Determination of Basic Requirements of Farm Structures," by M. C. Betts, architect, U. S. Department of Agriculture. The presentation of this paper will be followed by discussions by prominent agricultural engineers and others on the opportunities for research in farm structures.

Are farm buildings an investment or an expense? This is one of the big questions confronting the Structures Division of the Society at the present time. It is a problem in which all agricultural engineers, including the building materials and building equipment interests, are keenly interested. The forenoon session of December 2 will be devoted entirely to this subject and will be opened with a paper by J. L. Strahan, agricultural engineer, Louden Machinery Company. The discussion following will be participated in by prominent agricultural engineers and others. While arrangements have not been completed, it is expected that this session will also feature a paper by an Ohio farmer on cutting labor costs by the efficient planning of farm buildings.

The afternoon session of December 2 will be devoted to a round-table discussion of the activities of the Division in relation to sensible development of farm structures. A special effort will be made to formulate at this session a definite program of organized attack on the outstanding problems in farm structures, under the general direction of the Structures Division.

North Atlantic Section Meeting

THE meeting of the North Atlantic Section of the American Society of Agricultural Engineers to be held at Webster Hall Hotel, Pittsburgh, Pennsylvania, October 19 to 21, inclusive, promises to be one of outstanding importance and interest to agricultural engineers and others directly interested in agricultural engineering in the eastern part of the United States. The program and arrangements are being developed with a great deal of care, and the indications are that the meeting will register an exceptionally large attendance.

The meeting will open Wednesday afternoon, October 19, with an address by the chairman of the section, C. I. Gunness, agricultural engineer, Massachusetts Agricultural College.

On account of the unusual interest in rural electrification, it is planned to have a special rural electrification session which will be held simultaneously with the general sessions. The papers to feature the general session at the three-day meeting include one by A. M. Goodman, agricultural engineer, Cornell University, on a season's campaign fighting the corn borer. R. E. Rogers will discuss the subject of painting farm buildings from the engineering and economic standpoints. The latest developments in the control of the strength of concrete will be presented by W. G. Kaiser, agricultural engineer, Portland Cement Association. F. T. Ransom will discuss the use of explosives in agriculture. Other subjects on the general program, for which speakers have not yet been announced, include (1) ways and means of reducing the cost of farm production, (2) recent developments in fruit and vegetable storage, (3) economics of farm structures and equipment, etc.

The rural electrification session will feature an address by Dr. E. A. White, director of the national Committee on the Relation of Electricity to Agriculture, reviewing the accomplishments in rural electrification. J. W. Purcell will discuss the development of rural electrification in the province of Ontario, Canada. W. D. Hemker, general engineer, Westinghouse Electric & Manufacturing Co., will present a technical discussion of the characteristics of electric motors for farm application.

Col. O. B. Zimmerman, president of the Society, will attend the meeting and is scheduled to address the meeting on matters of particular interest and import to agricultural engineers. Several prominent agricultural engineers from all parts of the country will be in attendance at the meeting. The indications are that the meeting will draw a large attendance outside of the territory of the section.

The banquet and business meeting of the Section will be held on Friday evening, October 21.

The meeting headquarters will be at the Webster Hall Hotel in Pittsburgh. All sessions of the meeting will be held there, with the exception of those scheduled for Friday morning and afternoon, which will be held at the plant of the Westinghouse Electric & Manufacturing Company in East Pittsburgh. As Webster Hall Hotel is a bachelor hotel, arrangements have been made with the Schenley Hotel, two blocks away, to accommodate those members who bring their wives. Those who come by train are advised to get off at Pittsburgh. Hotel reservations should be mailed direct to the chairman of the local arrangements committee, W. D. Hemker, general engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pennsylvania.

Power and Machinery Division Meeting

AN UNUSUALLY attractive program is being arranged for the meeting of the Power and Machinery Division of the American Society of Agricultural Engineers to be held at Hotel Sherman, Chicago, November 29 and 30. The arrangements for the meeting and program are being directed by the chairman of the Division, E. R. Wiggins, agricultural engineer, French & Hecht.

The four half-day sessions of this two-day meeting will each feature a subject of timely importance to members of the Society, especially interested in the activities of this Division and to the farm equipment industry.

The first half day of the meeting, on November 29, will be devoted to the subject of the "combine." The session will open with a symposium of reports of state and federal investigations, including also Canadian investigations, that have been made this year on the use of the combine. This will be followed by a discussion of recent developments of the combine, which will be participated in by engineers prominent in the development of this machine.

The afternoon session of the first day will feature the subject of crop drying, including the drying of both hay and grain. The progress of the national program of research in mechanical farm equipment will also be discussed at this session, the principal speaker being H. B. Walker, senior agricultural engineer of the U. S. Department of Agriculture, who is directing the Department's research survey in this field.

The forenoon session of November 30 will feature recent developments in tillage machinery. F. A. Wirt, of the J. I. Case Threshing Machine Company, will present a paper on the application of the "disk harrow-plow," duck-foot harrow,

rotary hoe, etc. This will be followed by a discussion of other phases of tillage development, including the influence that progress in pest control, notably the corn borer, and other developments in agriculture are having on the need for changes in tillage practices. A paper on the subject of mole drainage will also be presented at this session by O. E. Robey, agricultural engineer, Michigan State College.

The afternoon session of November 30 will feature a paper on recent changes in tractors as noted from the Nebraska tractor tests to be presented by H. L. Wallace, engineer in charge of the Nebraska tests. It will be followed by discussions by engineers in the tractor industry on recent developments in tractor design. Inasmuch as control by mechanical means is generally admitted to be one of the principal features of the corn borer control campaign, discussions on the progress of the control work and future needs will be an outstanding feature of this session. The principal speaker on this subject will be C. O. Reed, engineer in charge of the corn borer control forces of the federal government.

On each day of the meeting of the Division, between 5:00 and 6:00 p.m., motion pictures will be shown portraying the latest developments in farm machinery.

The Society of Automotive Engineers will hold a one-day tractor meeting, December 1, at the Hotel Sherman, Chicago. The program for this meeting will be announced later.

Another Boost for the Bureau

THE editors of this journal have just had brought to their attention a resolution adopted at the convention of the California Associated Concrete Pipe Manufacturers held in San Francisco, July 15, 1927, requesting that the Secretary of Agriculture take steps to create a bureau of agricultural engineering in the U. S. Department of Agriculture. The effort to create this bureau, which was initiated in the first place by the American Society of Agricultural Engineers, seems to have met with general approval. Not only have the members of the Society individually urged the Department of Agriculture to take such action, but individuals and organizations whose interests are closely related to the Society's activities have backed up the Society's urgent appeal for the establishment of such a bureau. The action of the California Associated Concrete Pipe Manufacturers is particularly gratifying. The resolution adopted by this organization is as follows:

"WHEREAS the United States Department of Agriculture is looked to for leadership and direction in the advance which present conditions demand that agriculture in this country shall make forthwith, in order that those of our people who live wholly or in part by that basic industry may be enabled to maintain a standard of living not inferior to that which is afforded by other industry, and

"WHEREAS the history of other industry points unmistakably to the conclusion that a chief opportunity for this advance lies in increasing the ratio which agricultural production bears to the human effort of producing, and

"WHEREAS increase of this ratio will be in large part accomplished by a more efficient application of forces and materials in agricultural production, and

"WHEREAS agricultural engineering undertakes to bring forth ways, structures, machines, implements and assemblages of these calculated to effect the most efficient application of forces and materials to the purpose of agriculture, and

"WHEREAS the foregoing facts manifestly justify awarding to agricultural engineering in the United States Department of Agriculture a higher and more effective status than that now attaches, therefore be it

"RESOLVED that California Associated Concrete Pipe Manufacturers in convention here assembled in San Francisco on this fifteenth day of July, 1927, and having especially in mind the benefits obtained and to be obtained by and through agricultural engineering for irrigated agriculture, does hereby respectfully request the Secretary of Agriculture to take such steps as may be necessary to create in the United States Department of Agriculture a Bureau of Agricultural Engineering, and be it further

"RESOLVED that a copy of this resolution signed by the President and the Secretary of this California Associated Concrete Pipe Manufacturers be transmitted to the Honorable the Secretary of Agriculture, William M. Jardine."

(Signed) J. Fred Holthouse, President
(Signed) H. W. Chutter, Secretary

National Uniformity in Bolt and Nut Sizes

TABLES of standard sizes for square and hexagonal bolt head and nuts and for the corresponding wrench openings were recently approved by the American Engineering Standards Committee as a Tentative American Standard. The tables were established with much effort and care by a sectional committee appointed under the procedure of the A.E.S.C. by the organizations sponsoring this work, viz., the Society of Automotive Engineers and the American Society of Mechanical Engineers. The sectional committee, under the chairmanship of Prof. Arthur E. Norton, of Harvard University, is subdivided into several subcommittees, each dealing with a special subject. Subcommittee worked out the above mentioned tables. These deal with rough, semi-finished and finished square and hexagonal bolt heads and regular nuts, finished hexagonal cap screw heads, set screw heads, finished and semi-finished hexagonal jam nuts, hexagonal light nuts, hexagonal and square machine screw nuts, and stove bolt nuts, hexagonal castellated nuts, and wrench openings.

The new standard is meant to introduce national uniformity in a field where wasteful diversity has reigned for a long time. The sizes of bolt heads and nuts are intended to supersede all existing standards which have grown up from commercial standard bolt heads and nuts. The dimensions listed are in accord with the tendencies of recent years toward smaller sizes for bolt heads and nuts than were given by the "U. S. Standard" thus called because it was established by the Navy Department in 1868. However, such reduction has been made only after giving due consideration to the stresses in bolts and nuts and after exhaustive tests of samples had been made.

If bolts and nuts on the one hand, and wrenches on the other hand, are made in accordance with the new standard, all wrenches of a certain size will match in a mechanically perfect manner all bolt heads and nuts of the same nominal size whatever their make may be. This will not only simplify stocks of materials and tools, but it will also give a considerable saving in time and effort in the work of the countless number of persons who have to use bolts and nuts as fastenings.

Copies of the standard may be obtained from the American Engineering Standards Committee, or the sponsor bodies, all located at 29 West 39th Street, New York City, at 35 cents a copy.

Personals of A.S.A.E. Members

G. A. Cumings has recently become associated with the U. S. Department of Agriculture, Bureau of Public Roads, in the capacity of associate agricultural engineer. He will give special attention to concentrated fertilizer distributing machinery.

A. B. Crane, extension agricultural engineer for the State College of Washington, is author of two recent bulletins issued by the extension service of that institution. The bulletins are entitled "Irrigation by Flooding in the Big Bend Section of Washington" and "Constructing a Wooden Hoop Silo."

A. D. Edgar recently resigned as instructor in farm mechanics at the Menominee (Michigan) Agricultural School to accept the position of assistant professor of agricultural engineering at the University of Idaho, Moscow.

Lee H. Ford has been placed in charge of industrial tractor sales at the St. Louis branch of the International Harvester Company.

W. J. Godtel, student trainee of the J. I. Case Threshing Machine Company, left for the Argentine September 1 for a stay of six months to set up and start combines for the company.

Max Greenler is one of the five men in the first class to take the rural electric training course recently established by the General Electric Company. He is a recent graduate of Ohio State University.

J. R. Haswell, extension agricultural engineer, Pennsylvania State College, is author of two new bulletins, entitled "Land Drainage in Pennsylvania" and "Septic Tanks for the Farm," recently issued by that institution.

Orve K. Hedden recently resigned as assistant professor in charge of farm mechanics at the Colorado Agricultural College to enter the division of agricultural engineering of the U.S.D.A. Bureau of Public Roads, as junior agricultural engineer to engage in research work on the corn borer problem. His new address is Apartment 409, The Scottwood, Toledo, Ohio.

(Continued on page 2—Advertising Section)

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O. B. ZIMMERMAN, President RAYMOND OLNEY, Secretary-Treasurer

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